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RADIOACTIVITY AND IONIZING RADIATIONS

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Summary

Definitions

Types of ionizing radiations

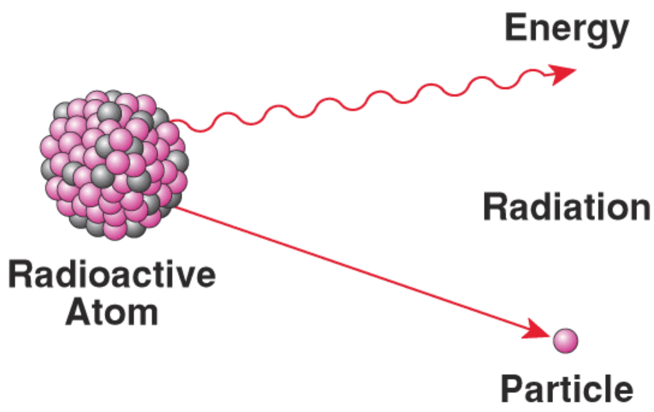
Radioactivity and units

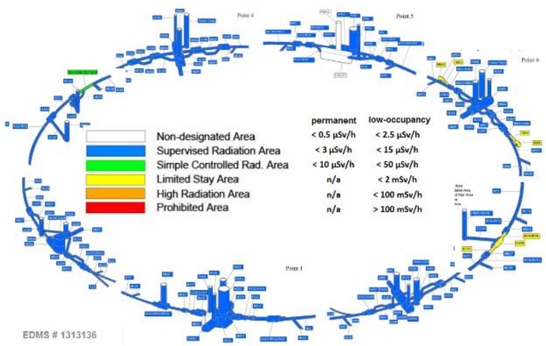
The effects of ionizing radiations

Natural and medical radioactivity

How to protect me ?

Measuring instruments





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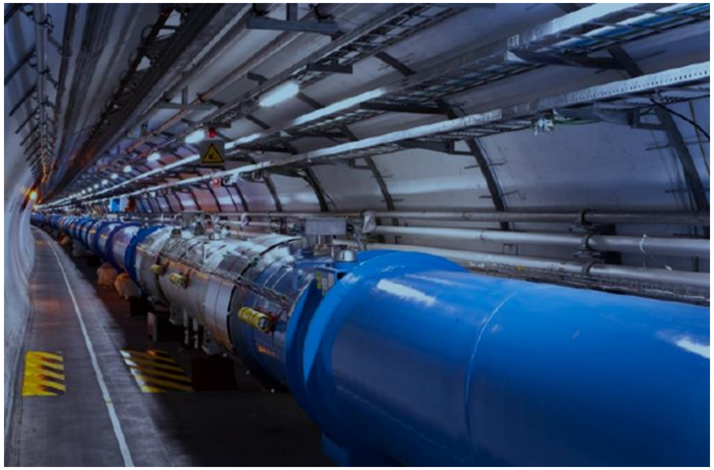
What is Radioactivity?

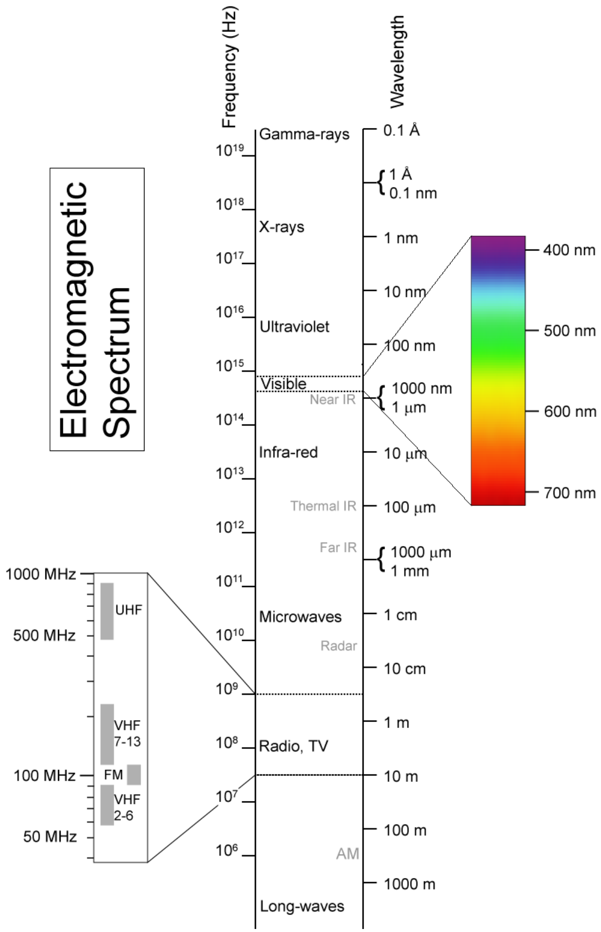
Elements that are RADIOACTIVE are UNSTABLE because they have too many particles or too much energy. In their attempt to become STABLE they give up particles or energy and this is…….

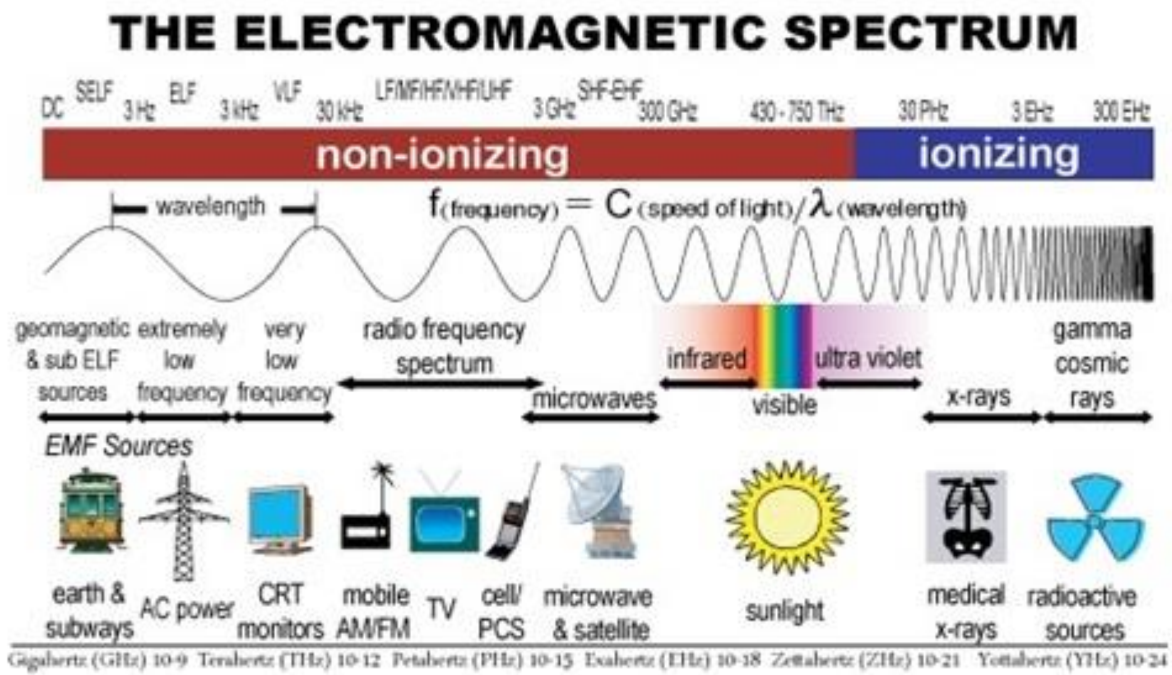
RADIOACTIVITY



The goal of Radiation protection is to protect humans against the effects of ionizing radiation while working with it.

Ionizing radiation





Different types of ionizing radiations:

1. Particles (neutrons, protons, alpha, beta)
2. Electromagnetical waves (gammas rays, X rays, photons)

Origin of radioactivity

Uncorrect balance between protons and neutrons.
→ unstable nucleus

⇩

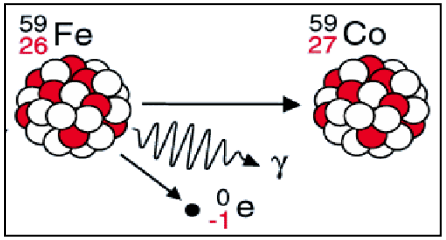
Internal reorganisation of the nucleus
(desintegration)

⇩

Energy release:
ionizing radiations

Activity

1 desintegration/second
=
1 Becquerel (Bq)



Radiation

Ionizing radiation
[energy deposit (Gy/h)]

Fundamentals

$^{238}_{92}U$

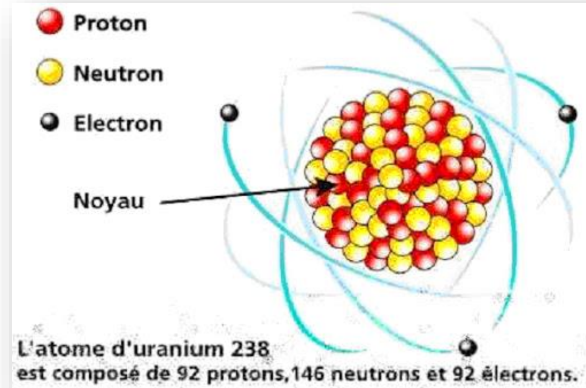
Uranium has :

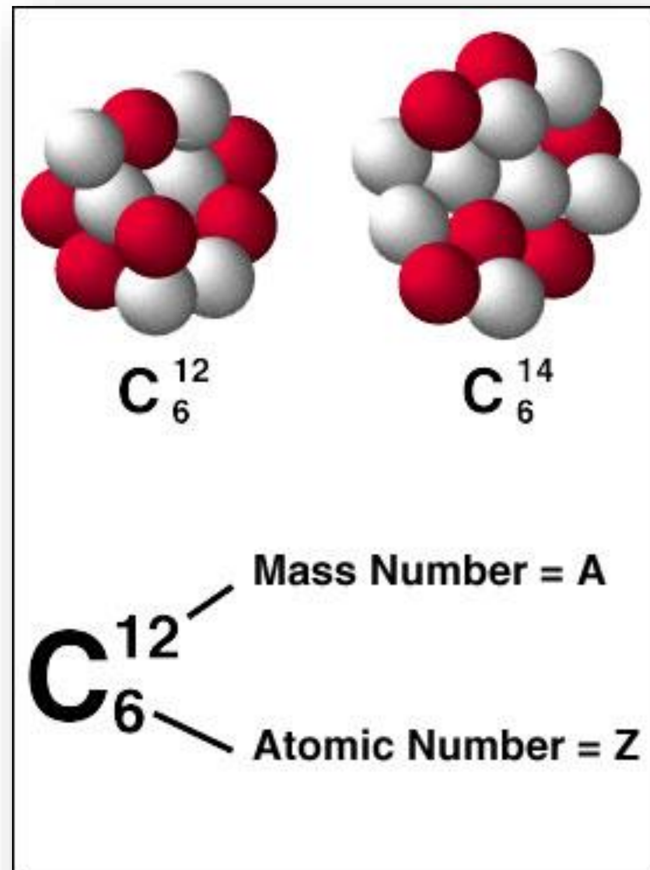
- 92 protons
- 146 neutrons
- 92 electrons

Mass Number

Isotopes : same Z ≠ A

$^{A}_{Z}X$





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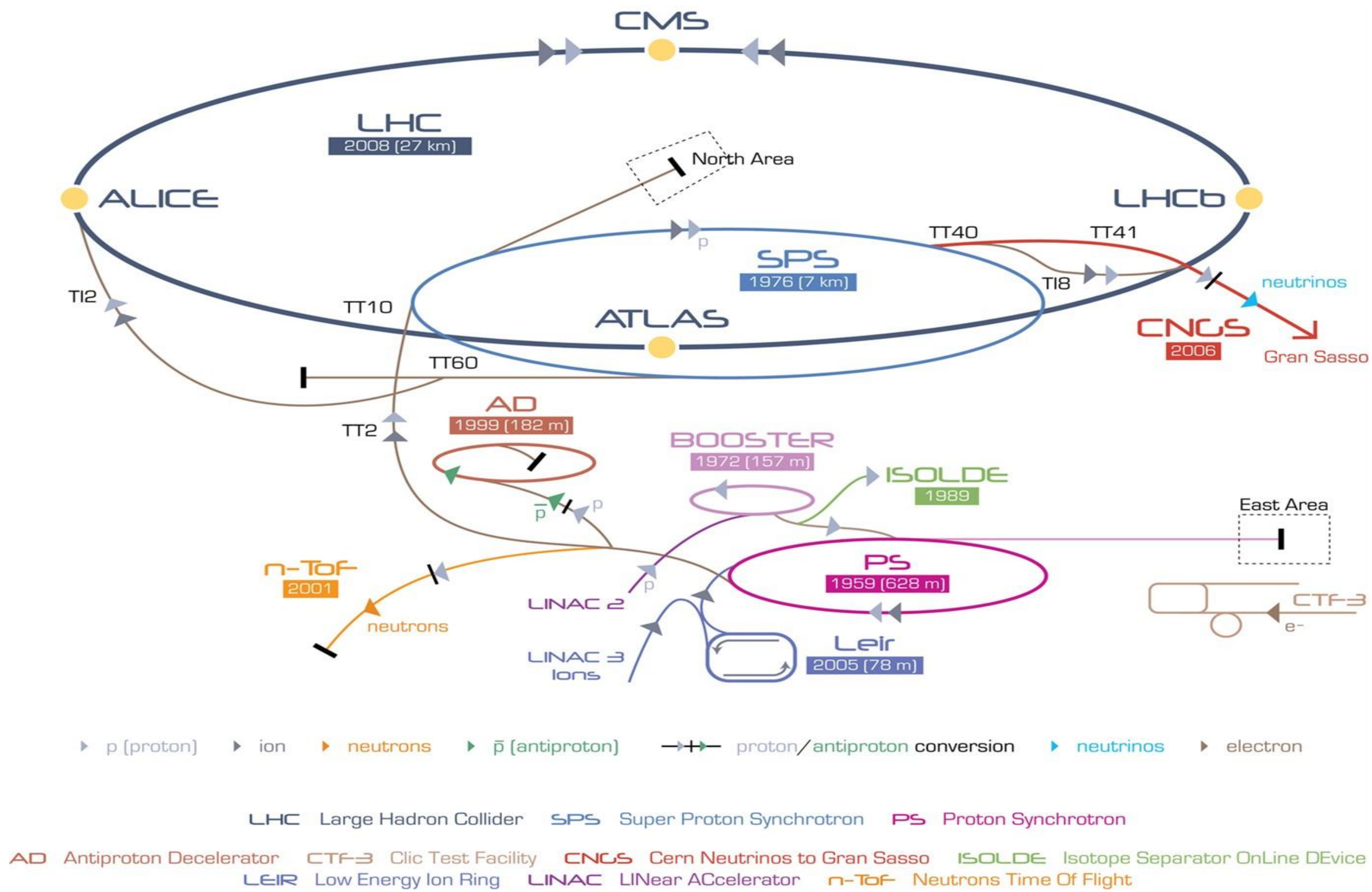
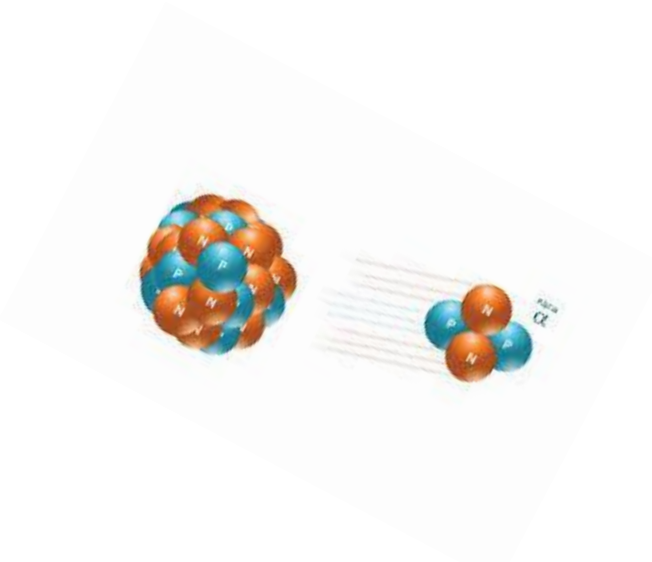
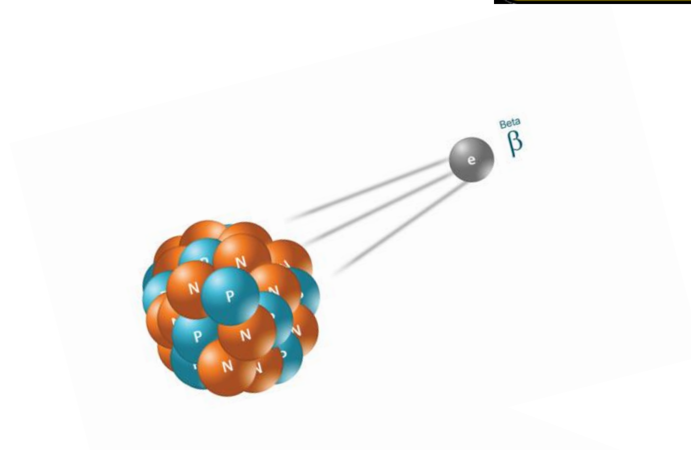
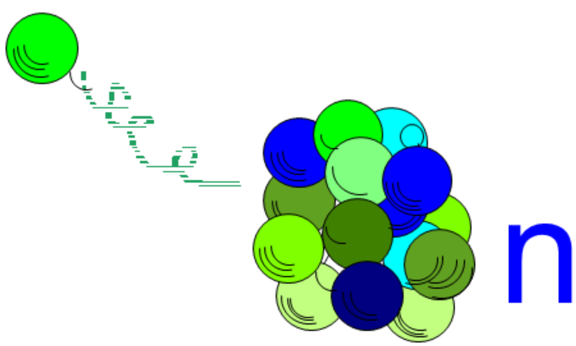
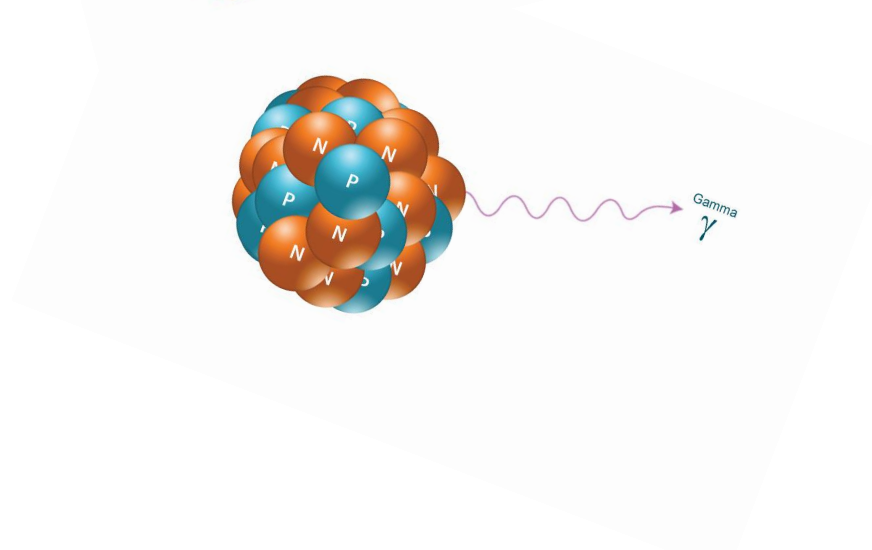

CMS
LHC
2008 (27 km)
North Area
ALICE
LHCb
TT40
TT41
SPS
1976 (7 km)
TI8
neutrinos
TI2
TT10
ATLAS
CNGS
2006
Gran Sasso
TT60
AD
1999 (182 m)
TT2
BOOSTER
1972 (157 m)
ISOLDE
1989
East Area
n-ToF
2001
PS
1959 (628 m)
LINAC 2
CTF3
e–
neutrons
LINAC 3
Ions
Leir
2005 (78 m)
p (proton)
ion
neutrons
p̄ (antiproton)
proton/antiproton conversion
neutrinos
electron
LHC Large Hadron Collider
SPS Super Proton Synchrotron
PS Proton Synchrotron
AD Antiproton Decelerator
CTF3 Clic Test Facility
CNGS Cern Neutrinos to Gran Sasso
ISOLDE Isotope Separator OnLine DEvice
LEIR Low Energy Ion Ring
LINAC LINear ACcelerator
n-ToF Neutrons Time Of Flight

Different types of radiation





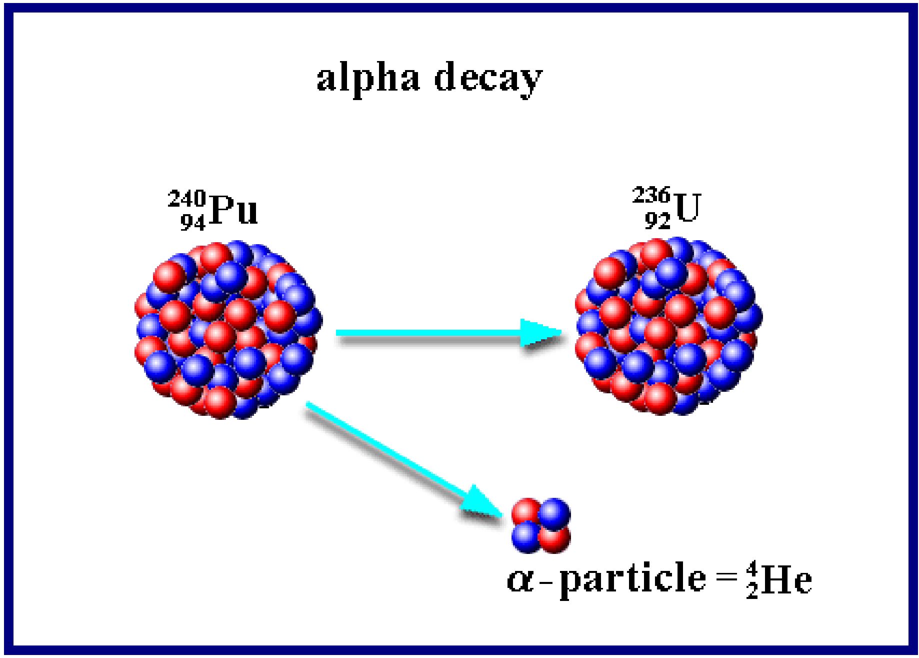




Alpha particles

The α particle :

- Helium nucleus (2 protons and 2 neutrons)
- Desintegration product of heavy nuclei
- Charged particle
- Free path of some µm in matter
  and some cm in air



- Non penetrating radiation (harmfull if ingested)
- Alphas at CERN : ISOLDE targets, radioactive sources for calibration (^{241}Am), sources for experiments (n-TOF)
- Can be stopped by a simple sheet of paper
- Hazardous effects on the body if ingested

Beta particles

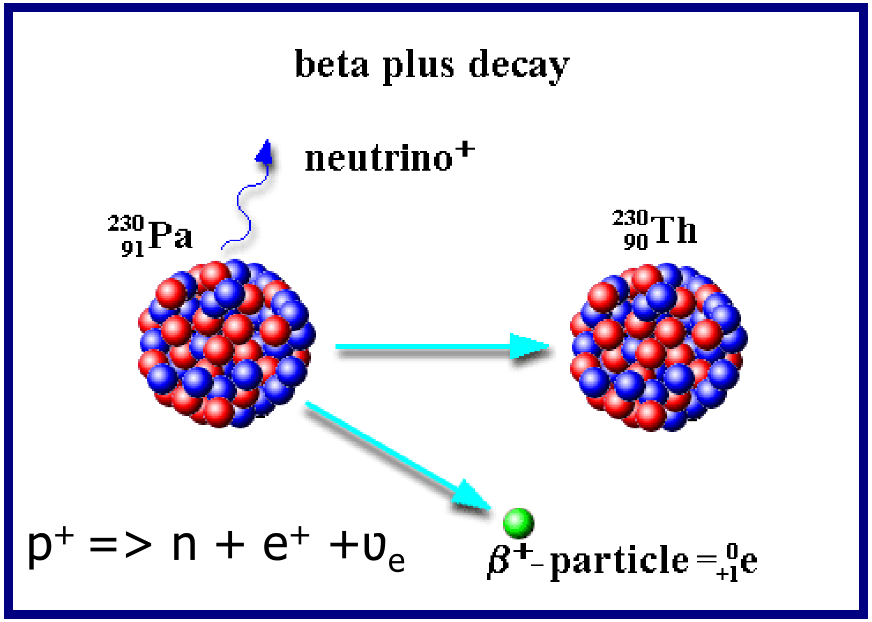
The β^+ or β^- particle :

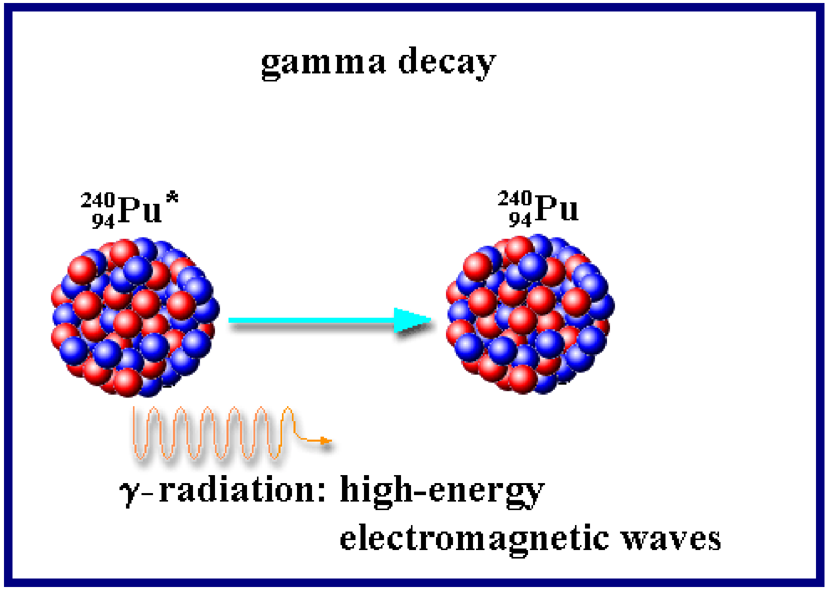
- Positron (e^+) or Electron (e^-)
- Produced by unstable nucleus

Presenting an excess of protons or neutrons

- Free path of cm in matter and m in air
- Non penetrating radiation (skin surface)
- At CERN : material activated in accelerators, sources, air

•Can be stopped by a light shielding





Gammas and X-rays

γ and X rays : electromagnetic raditations

- Produced by excited atoms or nuclei
- Free path of some m in matter and hundreds

  of meters in air
- Penetrating radiation (deep doses)
- At CERN : material activated by accelerator particles
- Shielding requires dense material (concrete, lead, iron)

x-rays are emitted by the electrons outside the nucleus, and gamma rays are emitted by the excited nucleus itself

Neutrons

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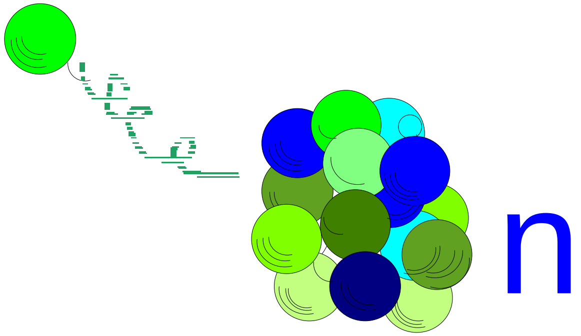
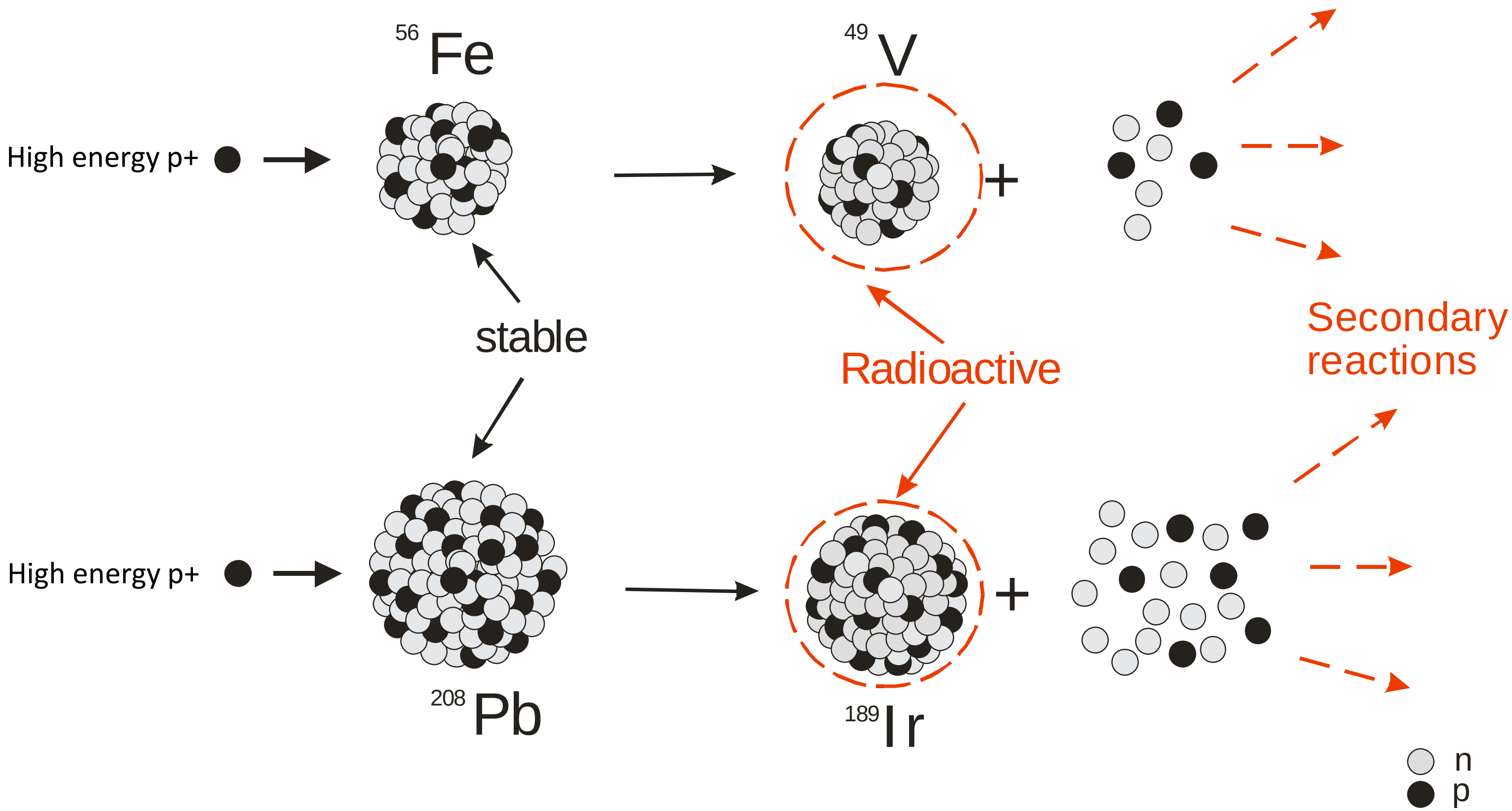
The neutron n :

- Non charged particle
- Coming from spontaneous fission reaction, fission in reactors or spallation around accelerators
- Free path of some m in matter and hundreds of m in air
- Penetrating radiation
- At CERN : beam losses, sources
- Can activate matter
- Can be stopped by matters rich in H (water, PET…)



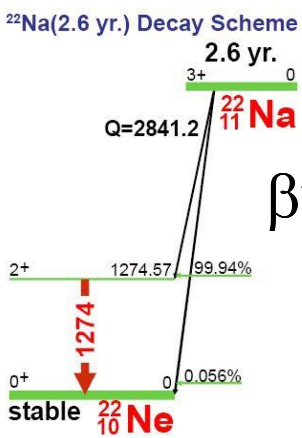
Spallation reactions



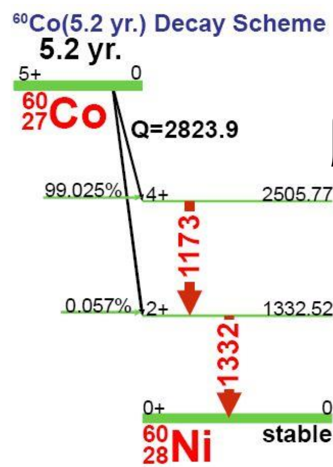
Isotopes production from stable atoms

Disintegration schemes

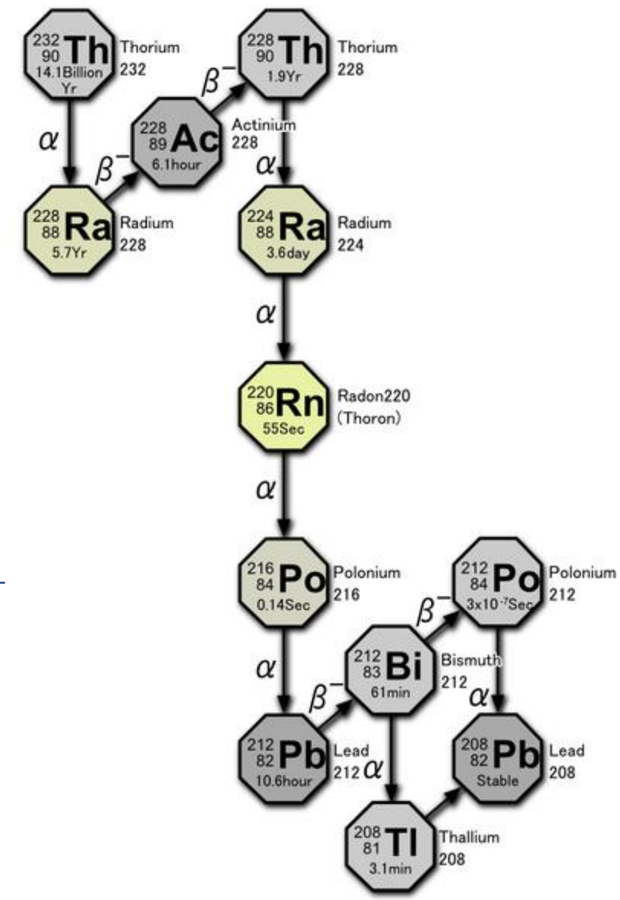
β-, γ-emitter:



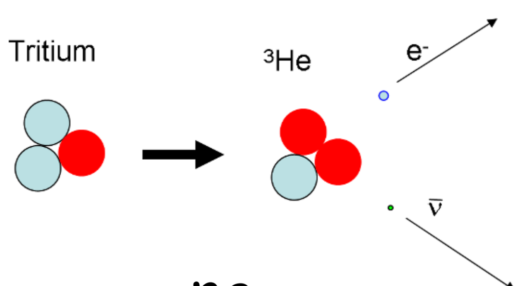
β+



β−

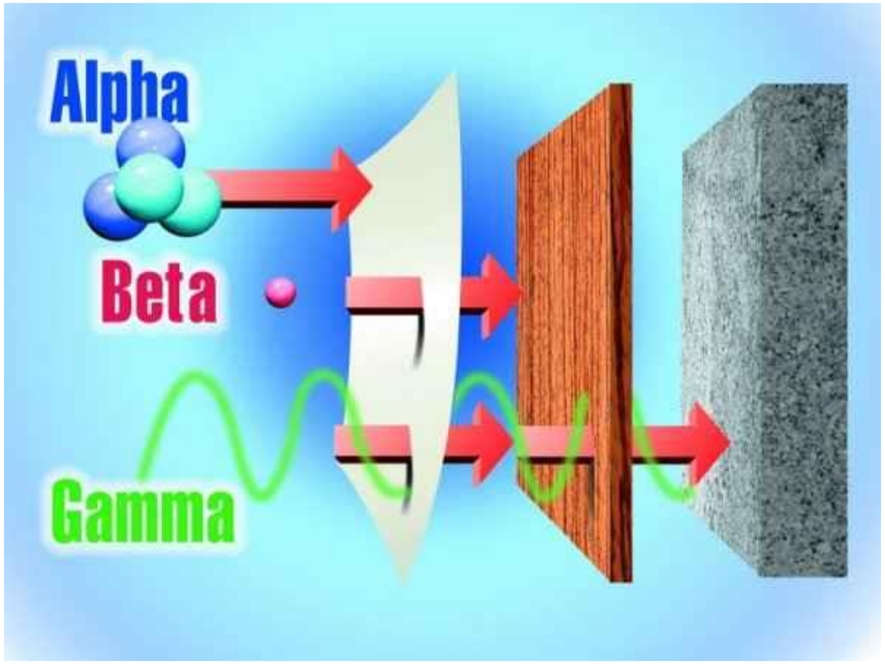


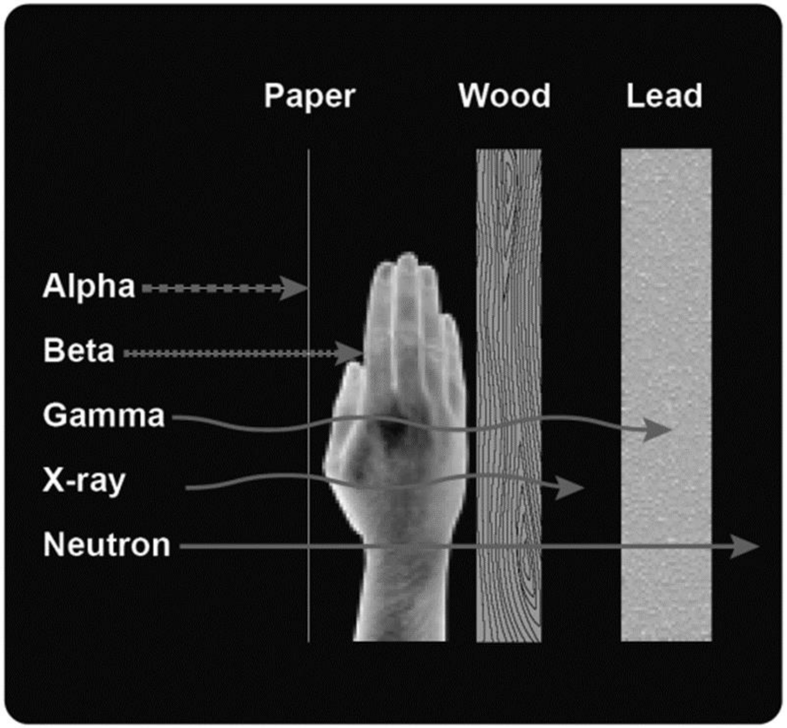
Pure β emitter :



no γ

Penetrating power of radiations

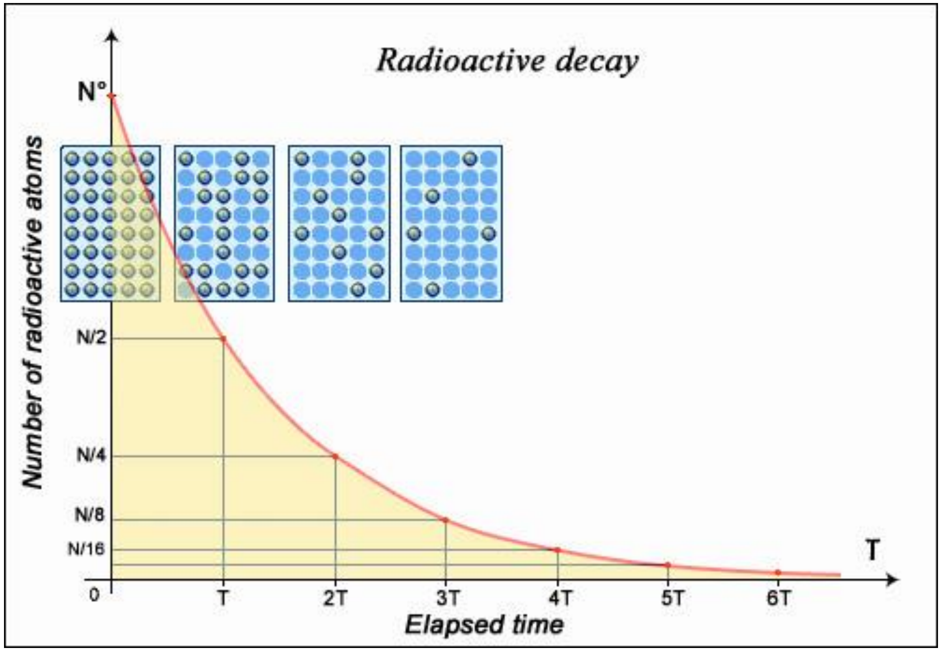




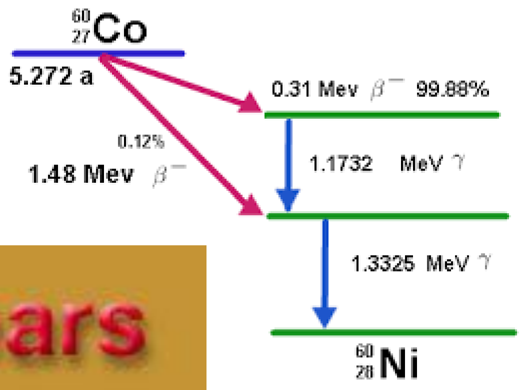
RADIOACTIVE HALF-LIFE: PERIOD

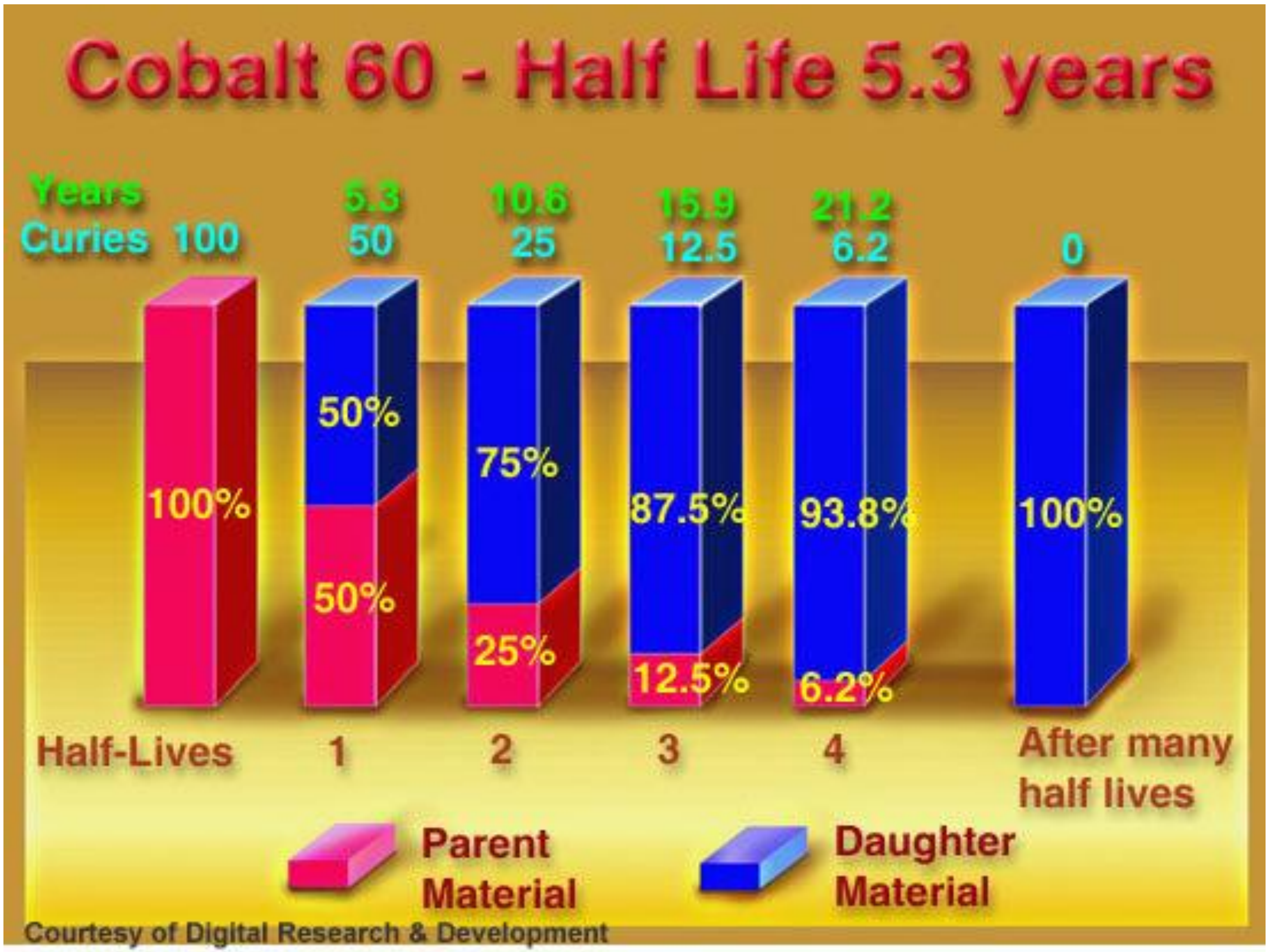
- **Half-life** is the period of time it takes for the activity of an isotope undergoing decay to decrease by half.
- In other words, after this time the original activity is divided by two

- Examples of half lives
  - Be-7 : T1/2=53.2 days
  - Co-60 : T1/2 = 5.27 years
  - C-11 : T1/2 = 20.38 min
  - U-235 : T1/2 = 7.10E8 years

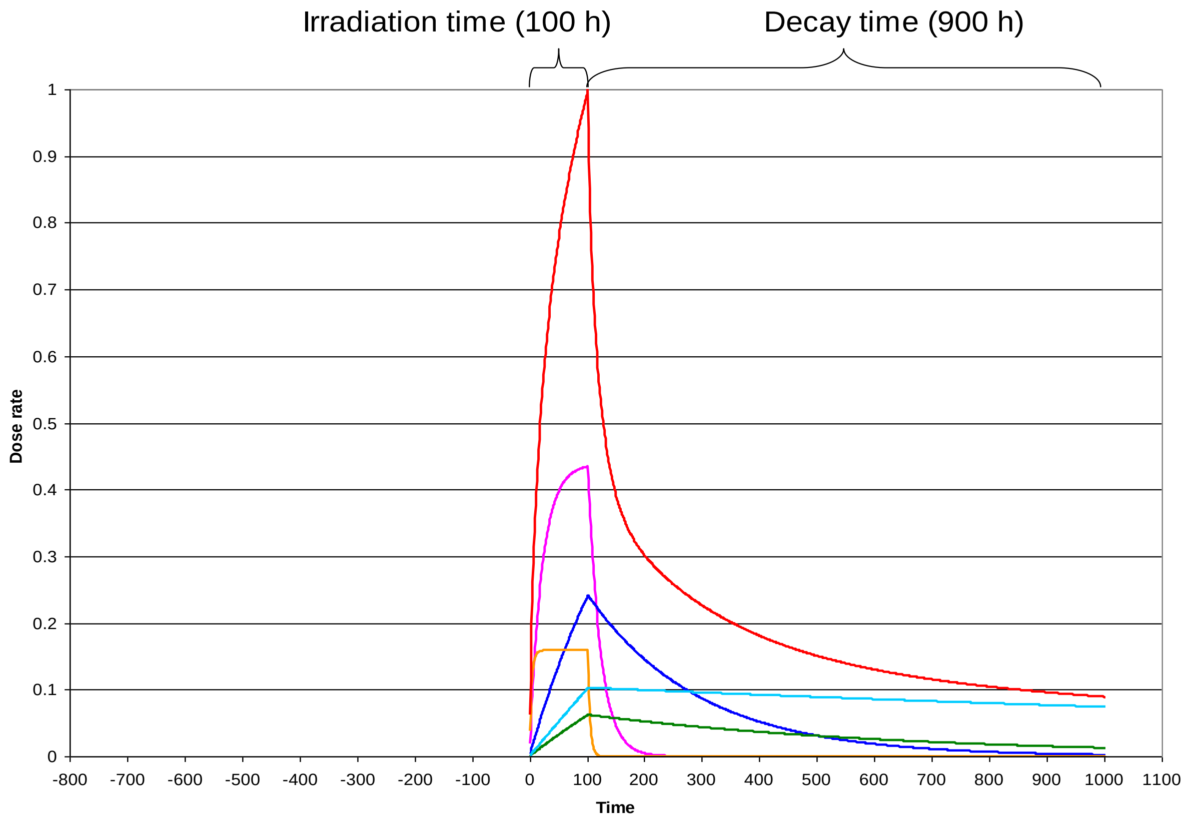


Radioactive half-life: example

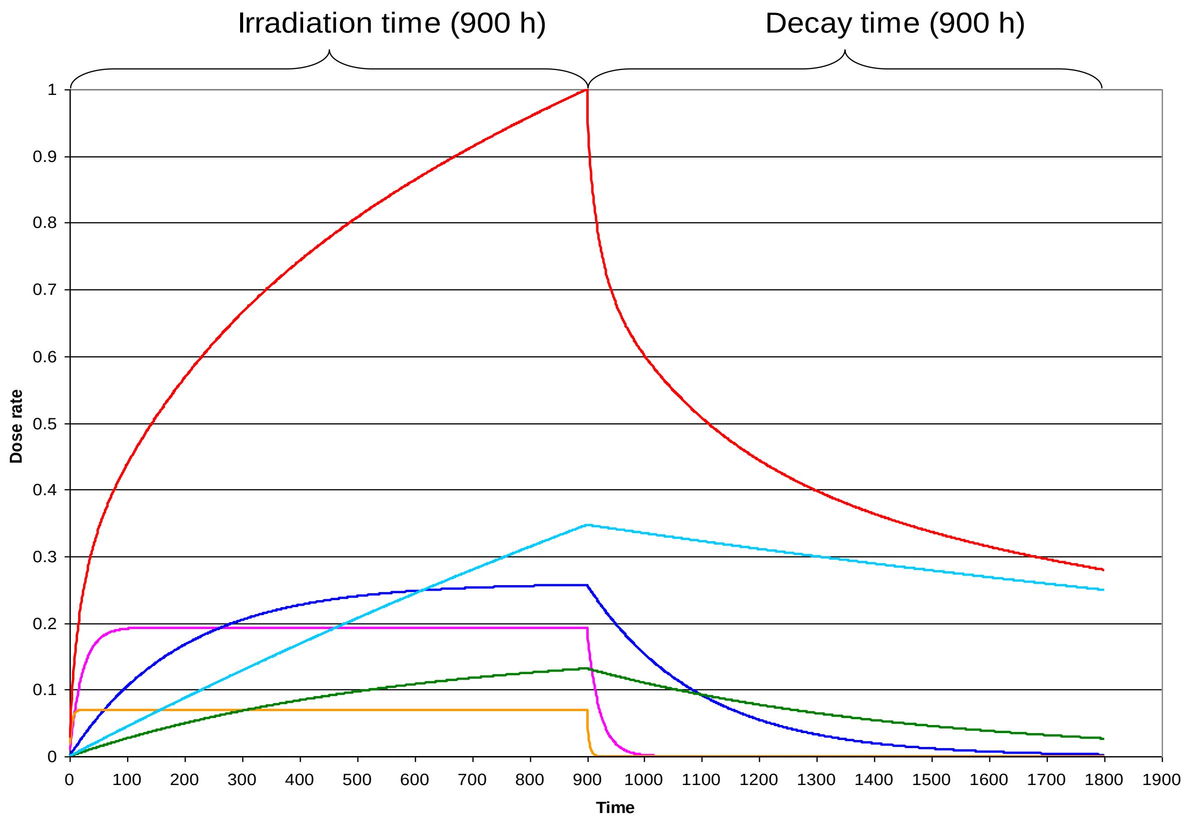




Activation and decay

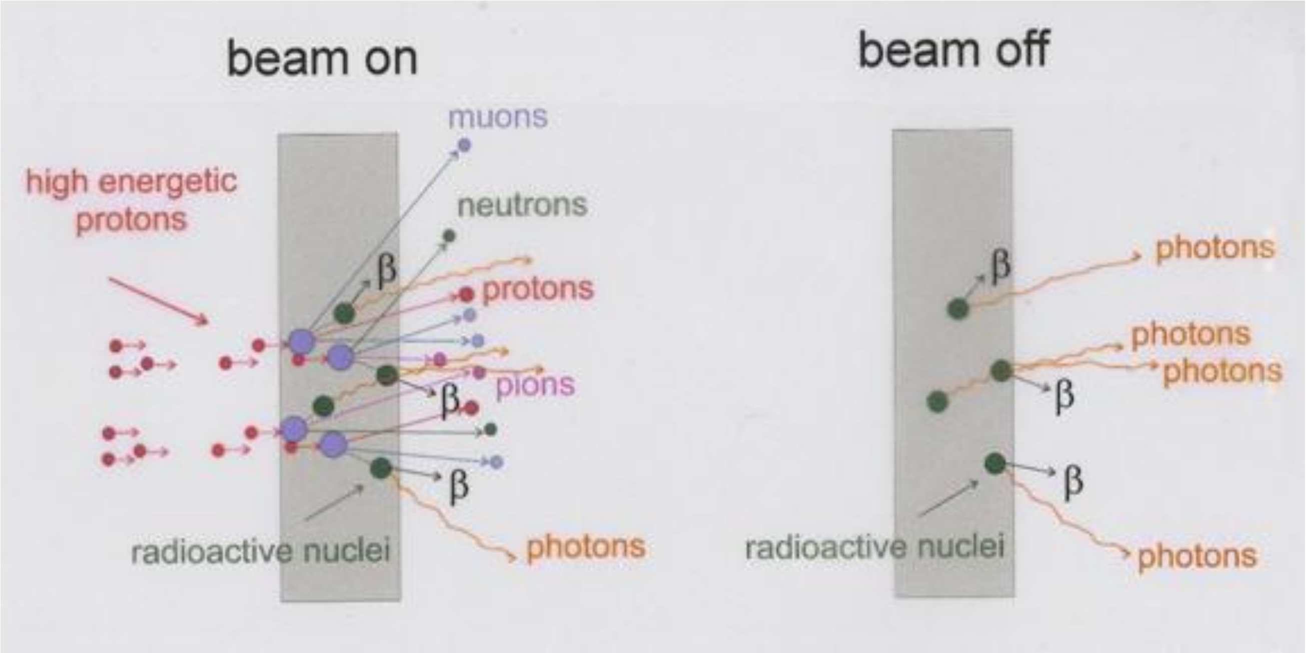


Activation and decay



Radioactivity at CERN

Main risks



Instantaneous radioactivity

Induced radioactivity

and some few more:

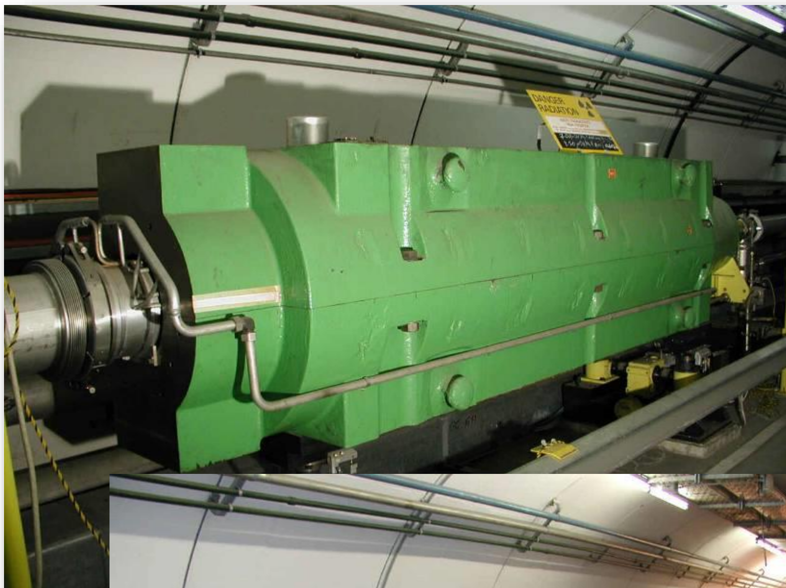
RF cavities

Klystrons

Radioactive sources

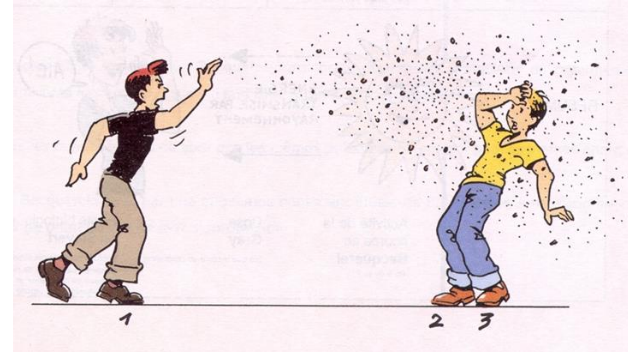
(a-, b-, g-radiations)

Activation in accelerators



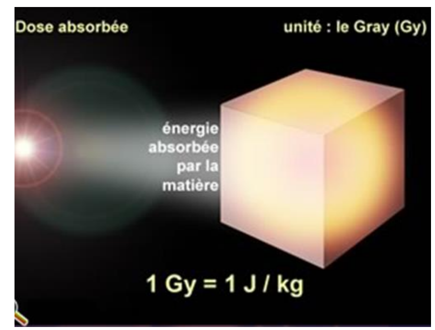
- *Beam losses in accelerators*
  - *particles interacting with vacuum chambers, magnets, walls...*
  - *All materials are becoming radioactive. The closest to the beam the higher it is activated*
  - *Losses are randomly distributed The activation is non homogeneously distributed.*

Units



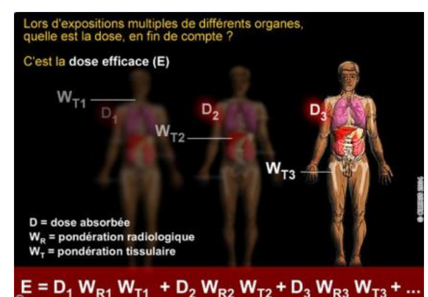
Experts distinguish between four types of radioactive quantities:

ACTIVITY : Bequerel, Bq
It is the number of disintegrations occurring per second,

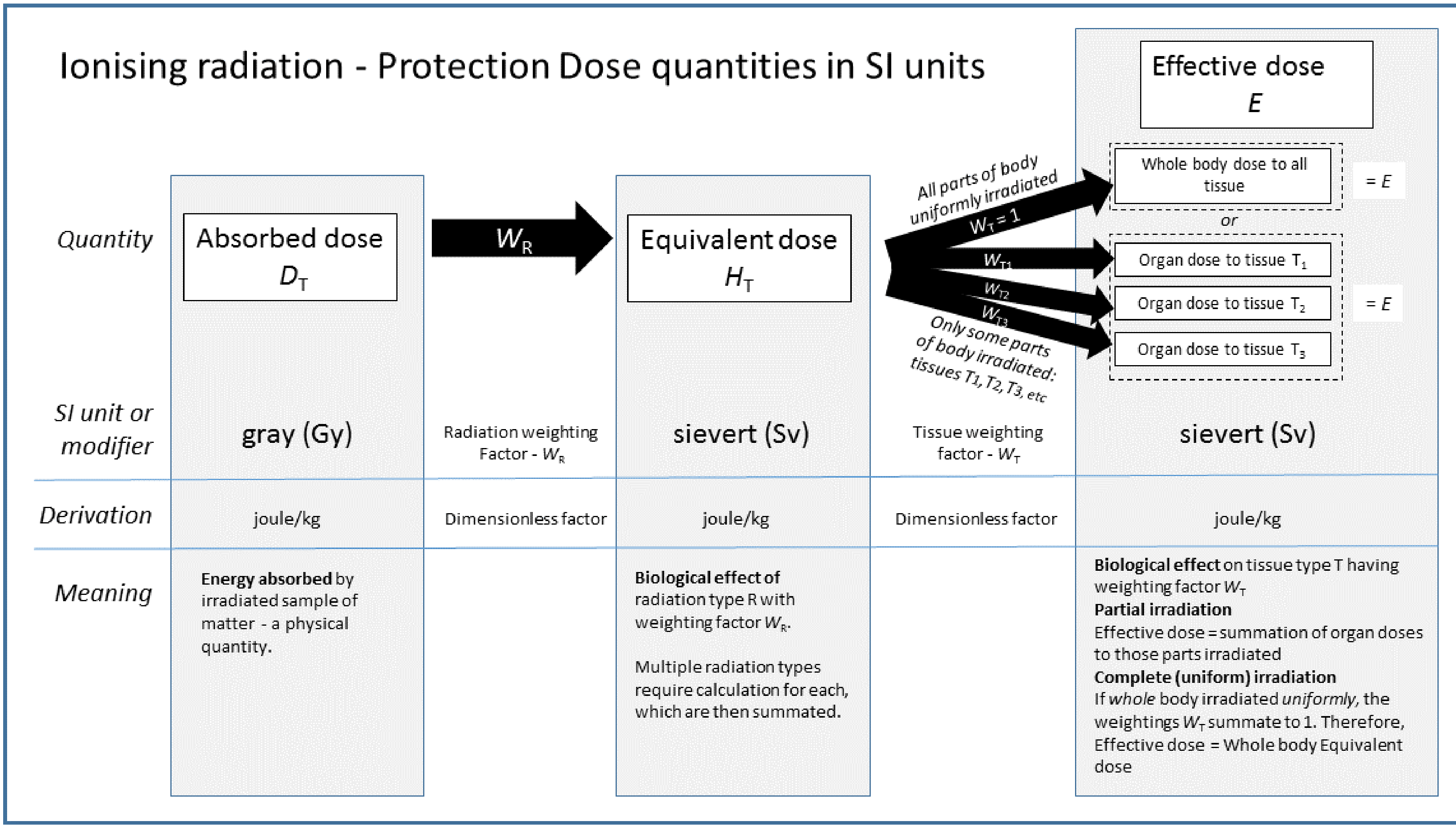


ABSORBED DOSE: Gray, Gy
Absorbed energy per mass unit (joule/kg)
Amount of energy deposited locally following an irradiation.

DOSE EQUIVALENT: Sievert, Sv
Biological effect of ionizing radiation taking care of type of radiation.



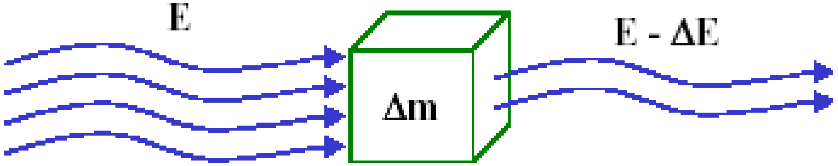
EFFECTIVE DOSE: Sievert, Sv
Calculus of the sum of equivalent doses on the different tissues and organs



Ionising radiation - Protection Dose quantities in SI units
Quantity
Absorbed dose D_T
W_R
Equivalent dose H_T
Effective dose E
All parts of body uniformly irradiated
$W_T = 1$
Whole body dose to all tissue
= E
or
W_{T1}
W_{T2}
W_{T3}
Organ dose to tissue T_1
Organ dose to tissue T_2
Organ dose to tissue T_3
= E
Only some parts of body irradiated: tissues T_1, T_2, T_3, etc
SI unit or modifier
gray (Gy)
Radiation weighting Factor - W_R
sievert (Sv)
Tissue weighting factor - W_T
sievert (Sv)
Derivation
joule/kg
Dimensionless factor
joule/kg
Dimensionless factor
joule/kg
Meaning
Energy absorbed by irradiated sample of matter - a physical quantity.
Biological effect of radiation type R with weighting factor W_R.
Multiple radiation types require calculation for each, which are then summated.
Biological effect on tissue type T having weighting factor W_T
Partial irradiation
Effective dose = summation of organ doses to those parts irradiated
Complete (uniform) irradiation
If whole body irradiated uniformly, the weightings W_T summate to 1. Therefore, Effective dose = Whole body Equivalent dose

Units : Absorbed dose

Absorbed dose (also known as **total ionizing dose**, TID) is a measure of the energy deposited in a medium by ionizing radiation. It is equal to the energy deposited per unit mass of medium, and so has the unit J/kg, which is given the special name Gray (Gy).



Dose Absorbée $(D = \Delta E/\Delta m)$

L'unité de mesure de la dose absorbée est le gray (Gy). L'ancienne unité de mesure était le rad (1 Gy = 100 rad). Les débits de dose (les doses rapportées à 1 heure) s'exprimeront en Gy/h ou rad/h

The Gray was expressed in rad until 1986 .

Units : dose equivalent

Dose equivalent (H) is calculated by multiplying the absorbed dose to the organ or tissue (D_T) by a radiation weighting factor, w_R.

This factor is selected for the type and energy of the incident radiation.

$$H_T = \sum_R w_R D_{T,R}$$

Where H_T = equivalent dose to tissue

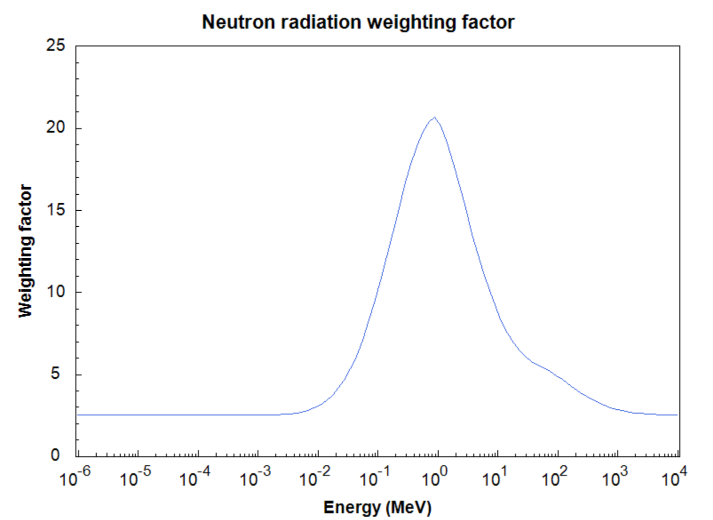
D_T = absorbed dose D (in Grays) to tissue

Recommended radiation weighting factors from ICRP 103 (2007)

Radiation type	Radiation weighting factor, w_R
Photons	1
Electrons[a] and muons	1
Protons and charged pions	2
Alpha particles, fission fragments, heavy ions	20
Neutrons	A continous function of neutron energy (see Fig. 1 and Eq. 1)

All values relate to the radiation incident on the body or, for internal radiation sources, emitted from the incorporated radionuclide(s).

[a] Note the special issue of Auger electrons discussed in ICRP 103 (2007).



Units : effective dose

Effective Dose (E) is calculated by multiplying the dose equivalent to the organ or tissue (H_T) by tissue weighting factor: W_T

$$E = \sum_{T} w_T \sum_{R} w_R D_{T,R} = \sum_{T} w_T H_T$$

This factor is selected for the type of tissues or organs being irradiated

The sum of effective doses to all organs and tissues of the body represents the effective dose for the whole body. If only part of the body is irradiated, then only those regions are used to calculate the effective dose. The tissue weighting factors summate to 1.0, so that if an entire body is radiated with uniformly penetrating external radiation, the effective dose for the entire body is equal to the equivalent dose for the entire body.

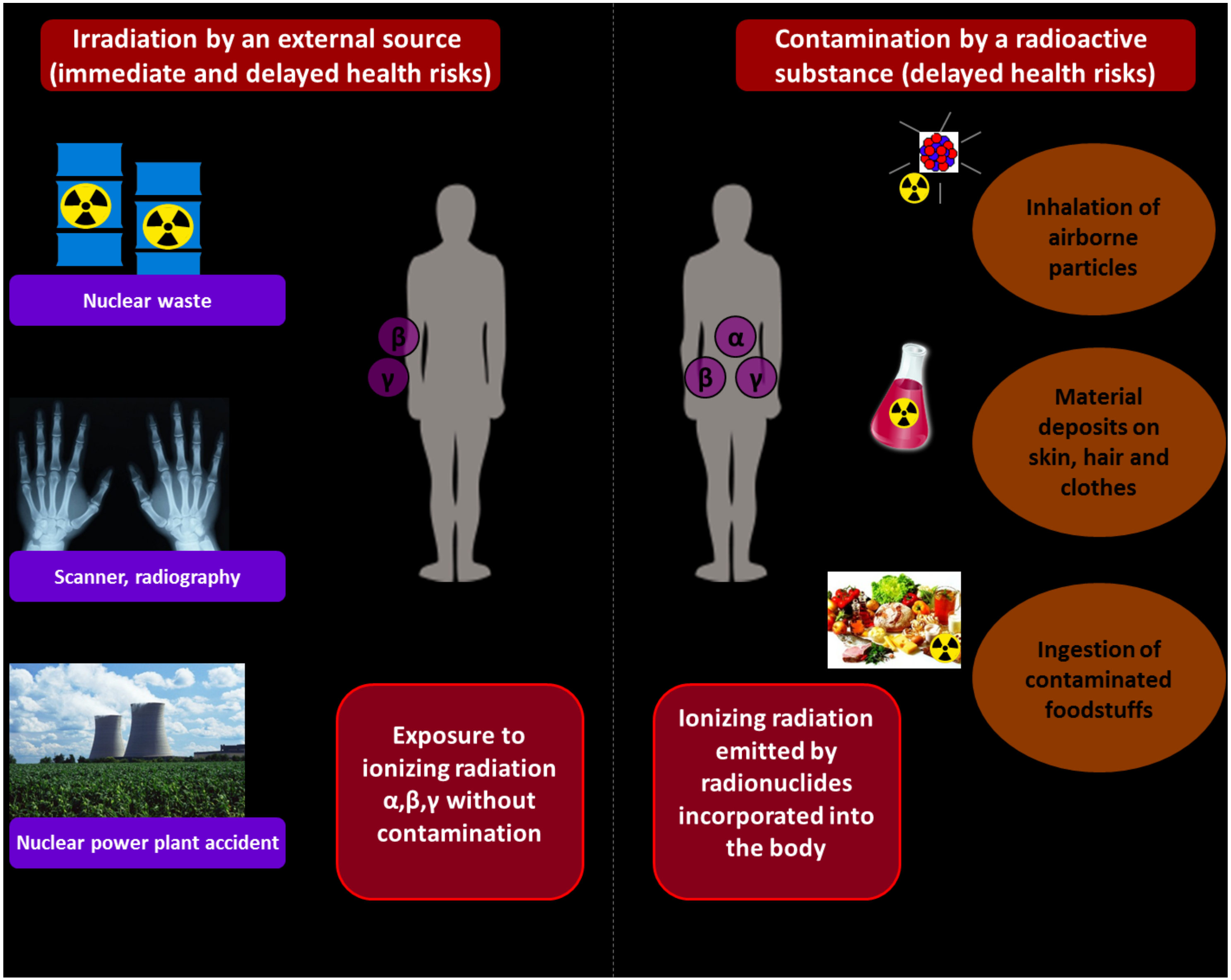
Weighting factors for different tissues[13]

Organs	Tissue weighting factors		
	ICRP26 1977	ICRP60 1990[14]	ICRP103 2007[15]
Gonads	0.25	0.20	0.08
Red Bone Marrow	0.12	0.12	0.13
Colon	-	0.12	0.19
Lung	0.12	0.12	0.16
Stomach	-	0.12	0.12
Breasts	0.15	0.05	0.12
Bladder	-	0.05	0.04
Liver	-	0.05	0.04
Oesophagus	-	0.05	0.04
Thyroid	0.03	0.05	0.04
Skin	-	0.01	0.01
Bone surface	0.03	0.01	0.01
Salivary glands	-	-	0.01
Brain	-	-	0.01
Remainder of body	0.30	0.05	0.12
Total	1.00	1.00	1.00

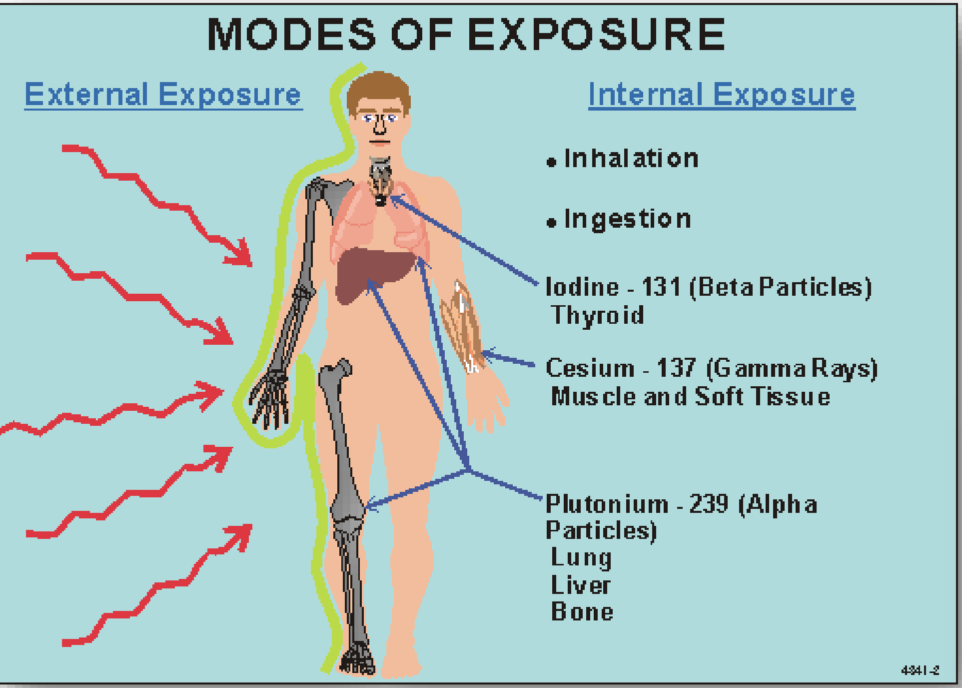
Units - old units – conversion factors

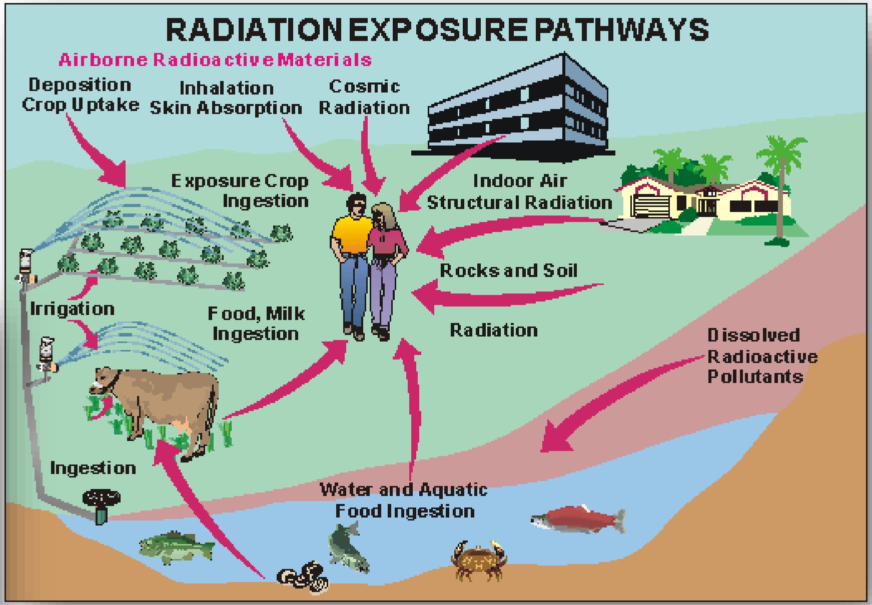
Value	SI Units (official)	Units (old)	Conversion	Definition
Activity	Bequerel [Bq]	Curie [Ci]	1Ci= 37 GBq	Disintegrations per second
Absorbed dose	Gray [Gy]	Rad [rad]	1 Gy = 100 rad	Energy deposition per unit of mass
Dose Equivalent	Sievert [Sv]	Rem [rem]	1 Sv = 100 rem	Quantification of the effects on the human body

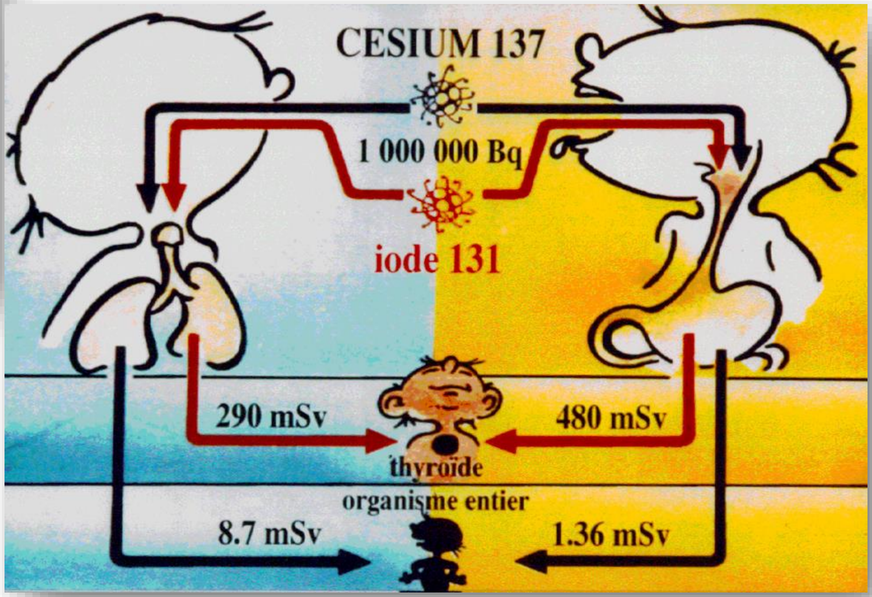
Difference between external exposure and contamination



External or internal exposition

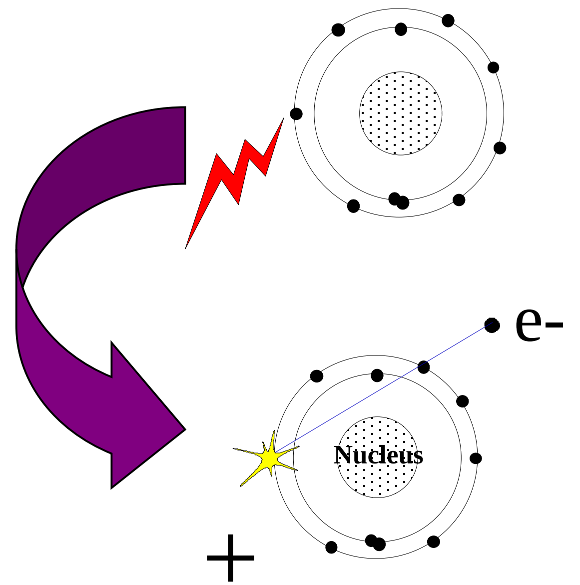




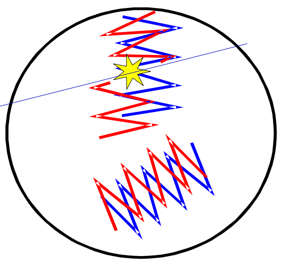


Biological effects of ionizing radiations ?

Ionization : the ionizing radiations are creating free electrons in matter, which are creating free radicals responsible of problems because they are very reactive .

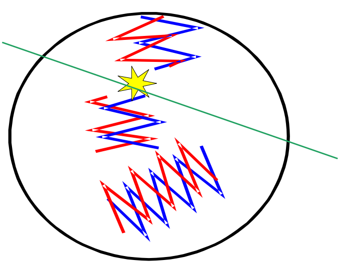


DNA breaks :



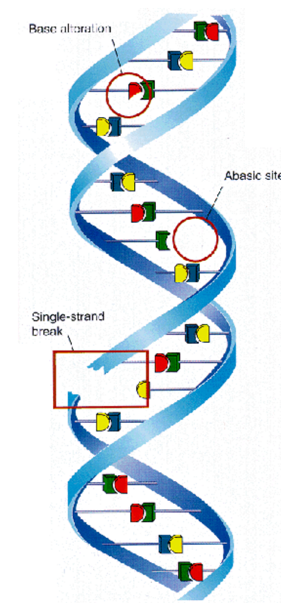
Single break event (β^-, γ) :

Cell will be repaired, will die or can mutate (rare)

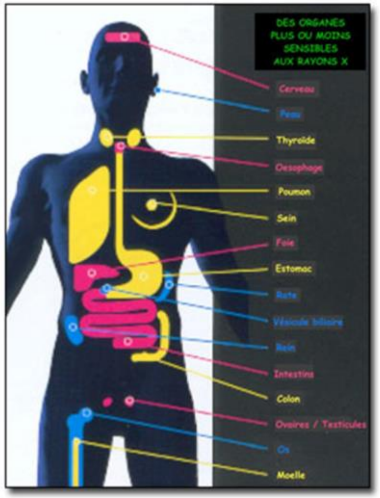


Double break events (n, α) :

Cell cannot be easily repaired, will die or mutate



Biological effects of ionizing radiations



- Radiation → energy absorbed by the body → Dose
- Ionization
  - Ionization of atoms and molecules in human cells
  - Ionized atoms and molecules do not behave like ordinary atoms and are disturbing normal processes

Stochastic effects

No treshold

- Effects arising with a certain probability
  - Genetical effects
  - Cancer inducing

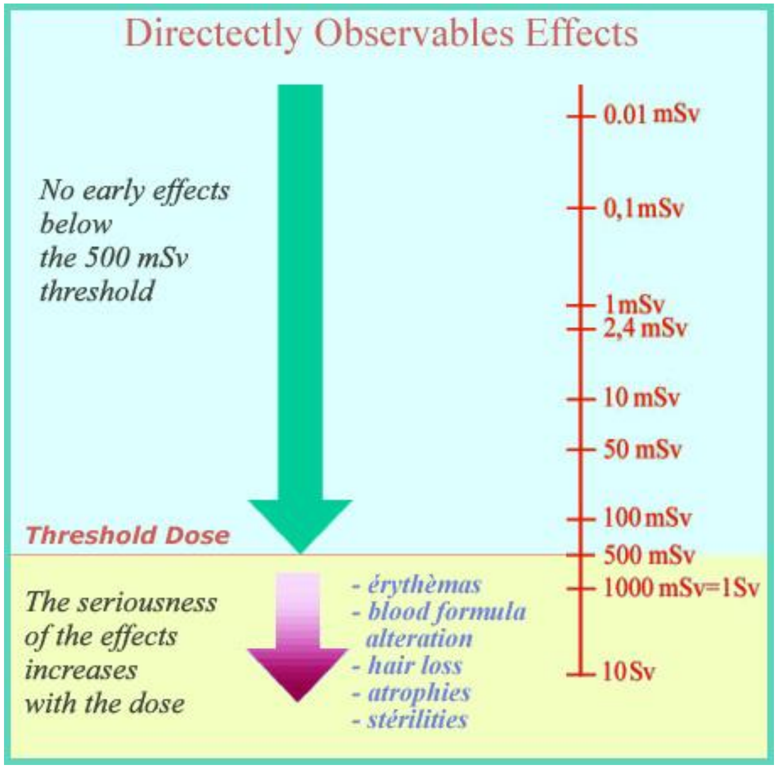
The affect are a function of the total dose absorbed and its distribution in time

Deterministic effects

- Big dose in small time > 500 mGy
- Immediate effects
  - erythema
  - nausea
  - immunodeficiency
- Directly function of the dose
- LD 50 : 5-7 Sv

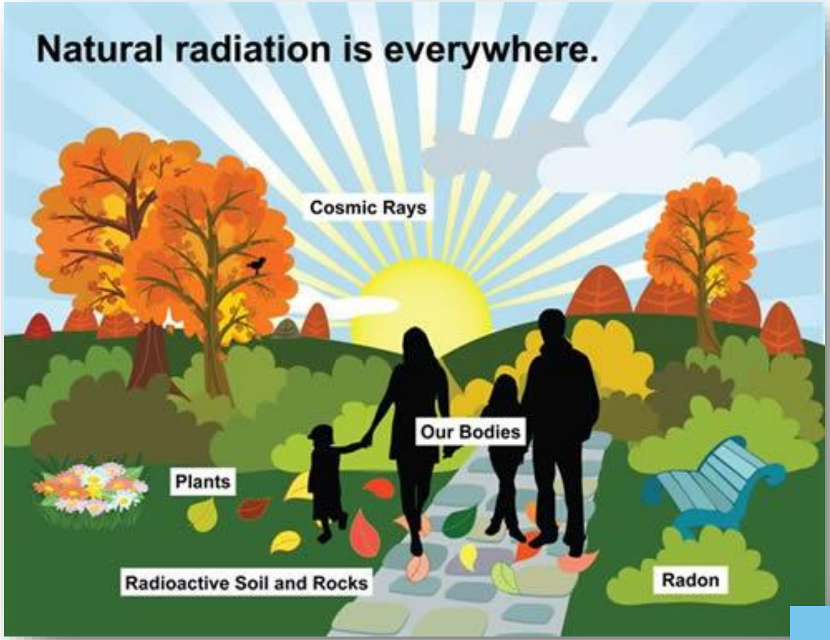
Radiological detriment = 5% per Sv :

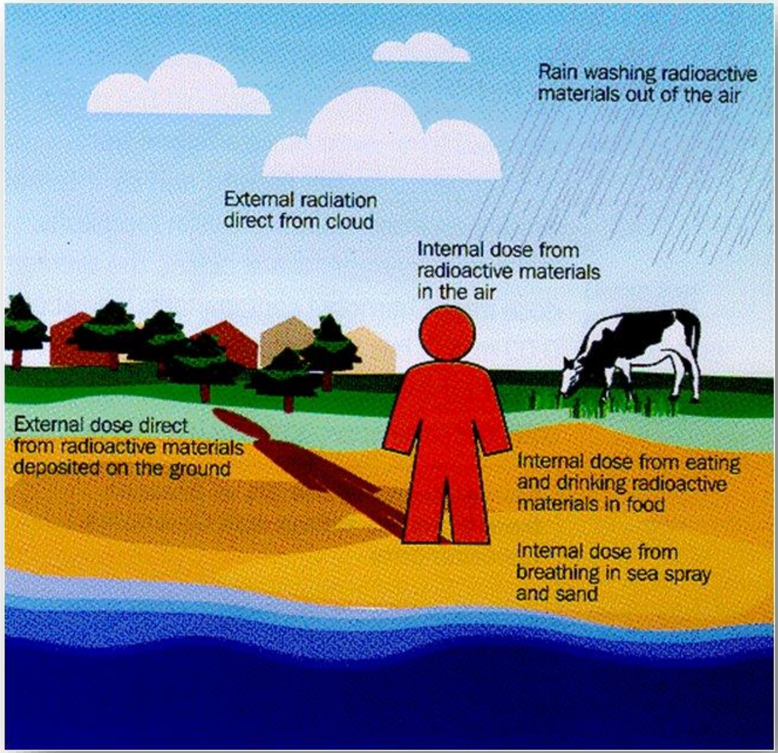
Biological effects: deterministics

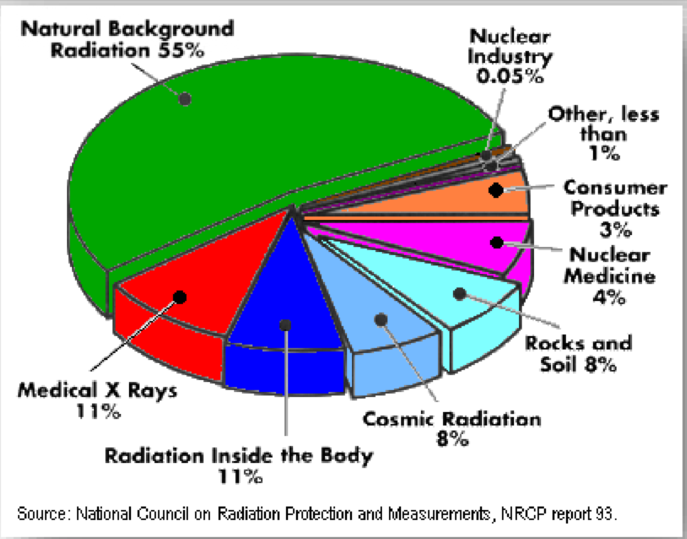


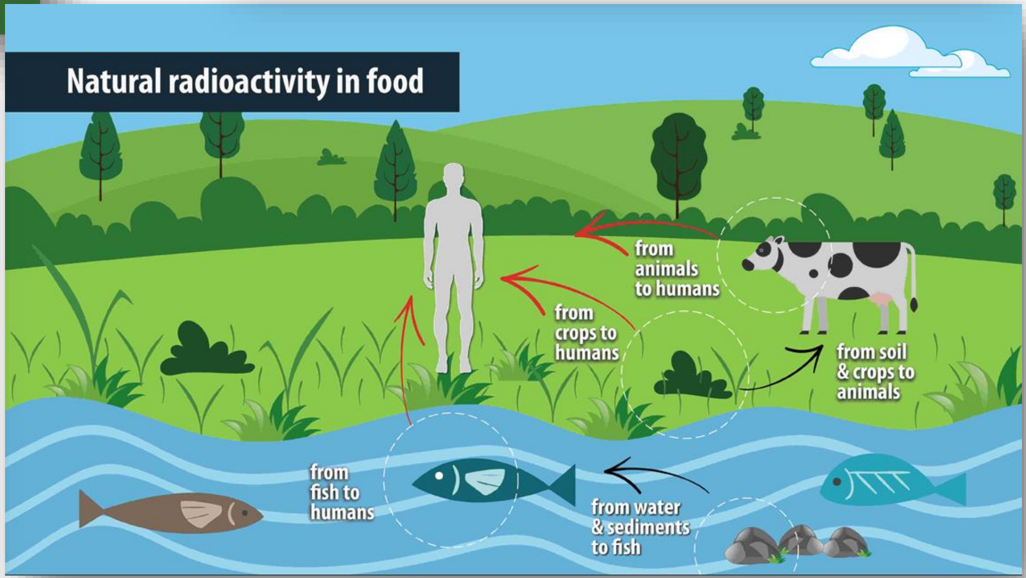
Acute Dose (mGy)	Effect
0-250	No detectable clinical effects. Delayed may occur, but are highly unlikely
250-1000	Slight blood change with later recovery. Possible nausea. Serious delayed effects are possible but improbable.
1000-2000	Nausea and fatigue, possible vomiting. Reduction in number of certain blood cells with delayed recovery.
2000-3000	Nausea and vomiting probable on first day. Two week latent period followed by general malaise, loss of appetite, diarrhea, moderate loss of weight. Possible death in 2-6 weeks but for most healthy individuals recovery likely.
3000-6000	Nausea, vomiting and diarrhea probable in first few hours. Short latent period followed by loss of appetite, general malaise, then hemorrhage loss of weight, skin blotches, diarrhea, inflammation of the throat. Some deaths in first weeks, possible eventual death to 50% of individuals receiving about 3500 mGy.
6000 or more	Nausea, vomiting and diarrhea in first hours. Short latent period followed by diarrhea, hemorrhage, skin blotches, inflammation of the throat, fever by end of first week. Rapid weight loss and death as early as second week with possible eventual death of 100% of exposed individuals.

Natural and medical radioactivity









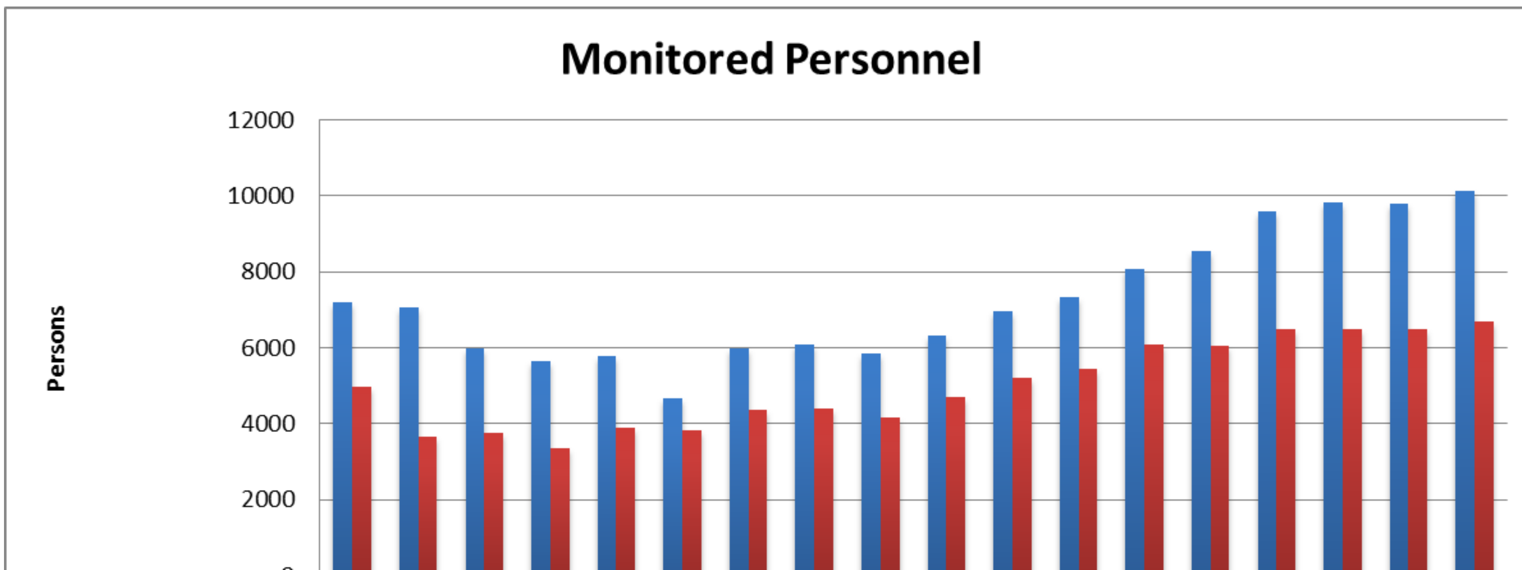
Natural and medical radioactivity

For this procedure:	* An adult's approximate effective radiation dose is:	Comparable to natural background radiation for:
ABDOMINAL REGION:		
Computed Tomography (CT)-Abdomen and Pelvis	10 mSv	3 years
CENTRAL NERVOUS SYSTEM:		
Computed Tomography (CT)-Head	2 mSv	8 months
Computed Tomography (CT)-Spine	6 mSv	2 years
Computed Tomography (CT)-Chest	7 mSv	2 years
Computed Tomography (CT)-Lung Cancer Screening	1.5 mSv	6 months
Radiography-Chest	0.1 mSv	10 days
DENTAL:		
Intraoral X-ray	0.005 mSv	1 day
HEART:		
Coronary Computed Tomography Angiography (CTA)	12 mSv	4 years
NUCLEAR MEDICINE:		
Positron Emission Tomography – Computed Tomography (PET/CT)	25 mSv	8 years
WOMEN'S IMAGING:		
Mammography	0.4 mSv	7 weeks
Note for pediatric patients: Pediatric patients vary in size. Doses given to pediatric patients will vary significantly from those given to adults. * The effective doses are typical values for an average-sized adult. The actual dose can vary substantially, depending on a person's size as well as on differences in imaging practices.		

2,5 to 6 mSv is the mean natural dose per year in CH

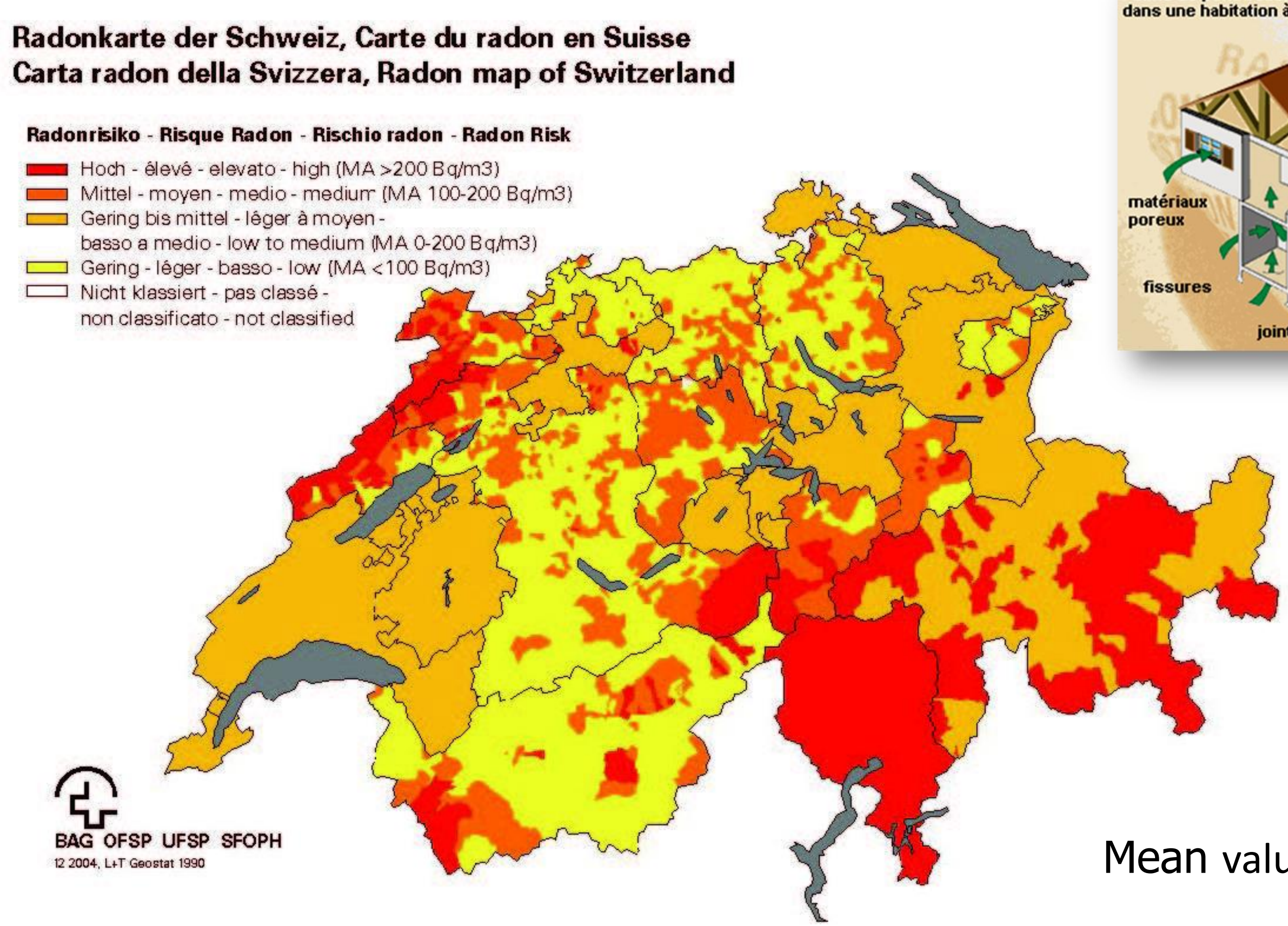
Radiation doses at CERN

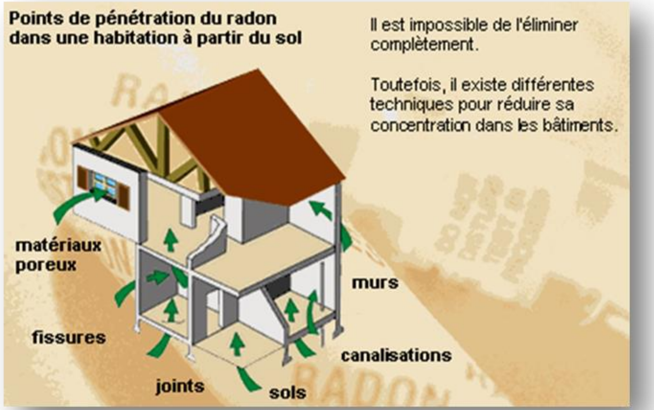
Dose interval (mSv)	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned	Persons Concerned
years	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0.0	4192	5131	5143	5042	5418	5315	6002	6273	7616	8704	8788	9034
0.1-0.9	1738	898	1020	1219	1514	1984	2030	2188	1816	1108	1003	1110
1.0-1.9	37	33	40	39	31	31	29	82	133	2	11	3
2.0-2.9	17	2	3	13	6	7	0	3	14	0	0	0
3.0-3.9	4	1	1	2	0	0	0	0	1	0	0	0
4.0-4.9	2	1	1	0	0	0	0	0	0	0	0	0
5.0-5.9	0	0	0	0	0	0	0	0	0	0	0	0
> 6.0	0	0	0	0	0	0	0	0	0	0	0	0
SUM PERS	5990	6066	6208	6315	6969	7337	8061	8546	9580	9814	9802	10147



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Monitored Personnel	7195	7080	5977	5646	5788	4666	5990	6082	5853	6315	6969	7347	8061	8546	9580	9814	9802	10147
Regular	4958	3661	3764	3372	3908	3844	4368	4400	4150	4717	5218	5463	6076	6054	6486	6503	6504	6702

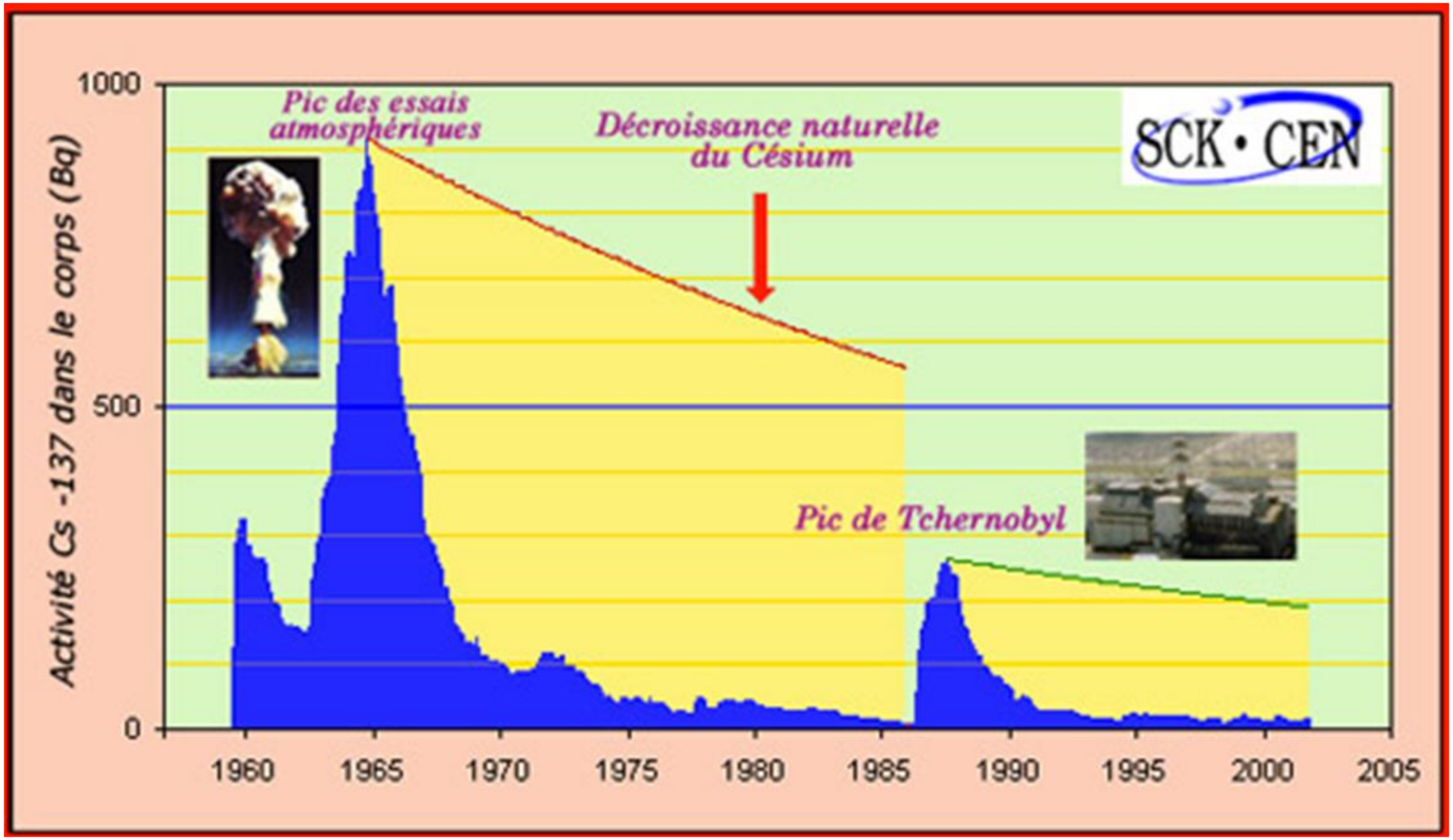
Radon occurrence in Switzerland





Mean value 3200 uSv/year

Natural background fluctuations



Evolution of internal contamination by 137-Cs

Regulations

HSE
Occupational Health & Safety
and Environmental Protection Unit

CERN radiation protection guidelines are inspired by the recommendations made by EURATOM in 2013
2013/59/EURATOM European entered into force 06 Feb 2014.

Directive EURATOM 2013/59

(CIPR) [CIPR103]

This directive has been adopted in Swiss and French regulations via, ordonnances, décrets, recommandations…

✓Décret n° 2002-460 du 4 avril 2002,
Protection générale des personnes contre les dangers des rayonnements ionisants,
J. O. de la République française n° 81 du 6 avril 2002 ;
✓Décret n° 2003-295 du 31 mars 2003,
Interventions en situation d'urgence radiologique et en cas d'exposition durable,
J. O. de la République française n° 78 du 2 avril 2003 ;
✓Décret n° 2003-296 du 31 mars 2003,
Protection des travailleurs contre les dangers des rayonnements ionisants,
J. O. de la République française n° 78 du 2 avril 2003 ;

(ORaP) réf. 814.501
26 Avril 2017 (état au 1er Janvier 2018);
Ordonnance utilisation sources radioactives non scellées
21 novembre 1997 (état au 23 décembre 2011)
réf. 814.554

Reference document at CERN => Security code F on Radiation protection EDMS 335729

Annual dose limits

Comparison between regulations for annual effective dose limits.

Regulations	Public [mSv/an]	Workers	
		B [mSv/an]	A [mSv/an]
EURATOM	< 1	< 6	< 20
FRANCE	< 1	< 6	< 20
CERN	< 0,3*	< 6	< 20
SWITZERLAND	< 1	< 20	

* chosen by CERN since the application of code F (in nov. 2006).

Annual dose limits : specific organs

Annual dose limits per work class

Body part exposed	Dose type	Public	Class **A** for 12 months	Class **B** for 12 months
Skin	Equivalent	50 mSv	500 mSv	150 mSv
Crystalline lens	Equivalent	15 mSv	20 mSv	15 mSv
Hands,feet	Equivalent	50 mSv	500 mSv	150 mSv

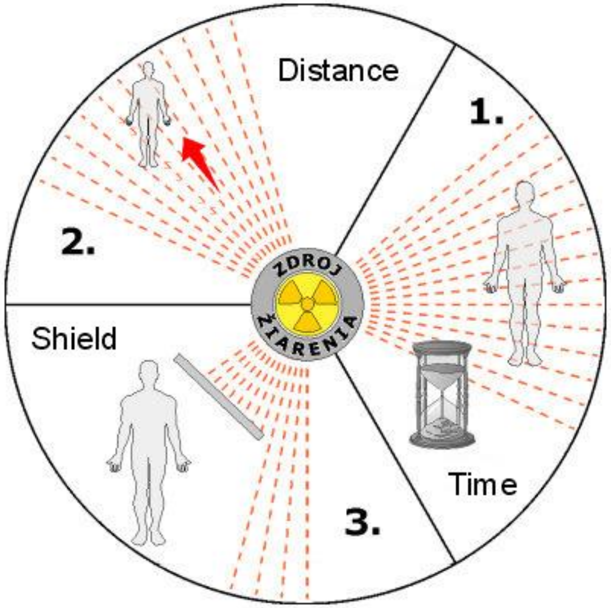
Annual dose limits : crisis and rescue

Professional exposition of persons working in a crisis situation, or a situation involving a radiological urgency, or for people protection (rescue operation)

Dose < 50 mSv.
Dose up to 250 mSv
(in order to protect or save lifes)

CONDITIONS

- ✓Voluntary workers classified in work category A,
- ✓Their names are known in advance,
- ✓Appropriate training concerning the possible risks
- ✓Workers are wearing appropriate dosimeters



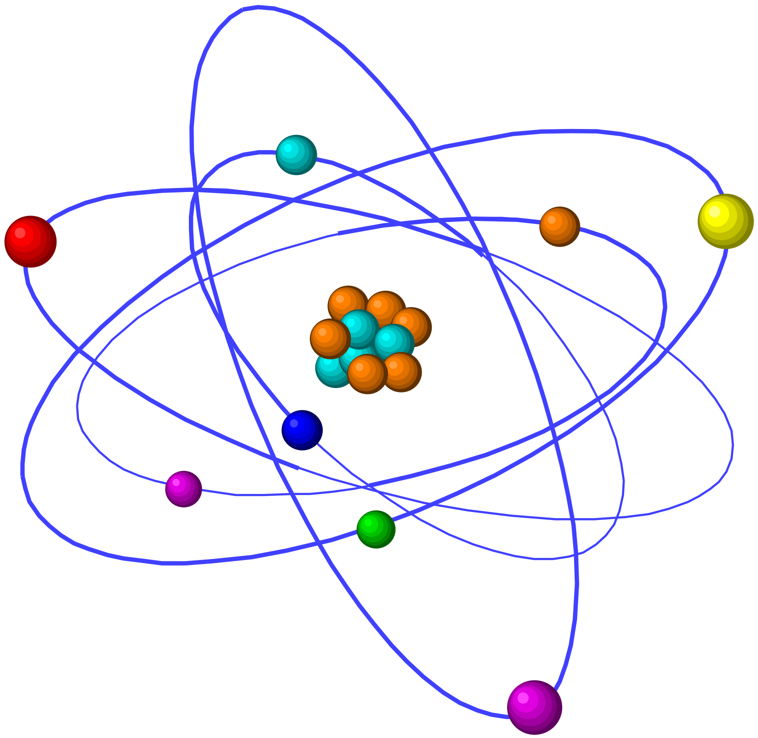
Fundamental principles of RP

✓**Justification**
Every exposition to ionizing radiation must be justified

✓**Limitation**
All individual doses must stay below legal values

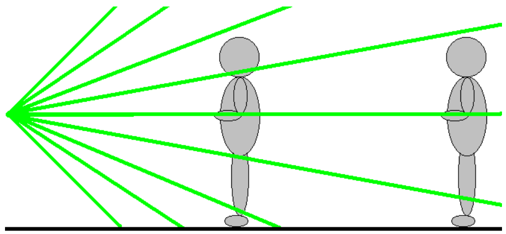
✓**Optimisation**
All individual doses must be restricted to a reasonable minimum (ALARA = "As Low As Reasonable Achievable").

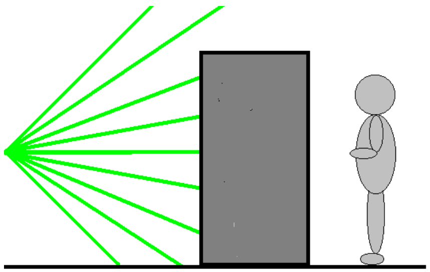
Radiocativity and ionising radiations



How to protect yourself ?

How to protect yourself ?



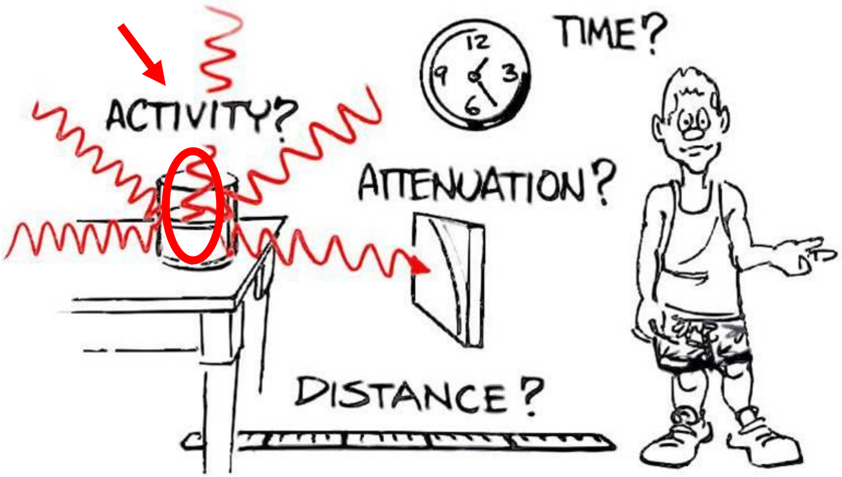


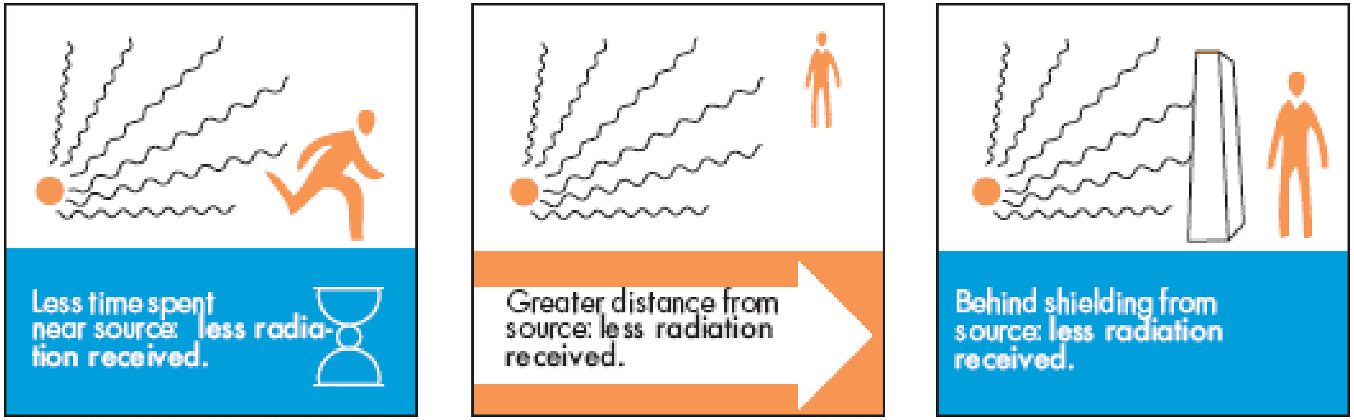
TIME
If you reduce exposition time, you will reduce the dose.

Distance
The further away to the source, the lower the dose.

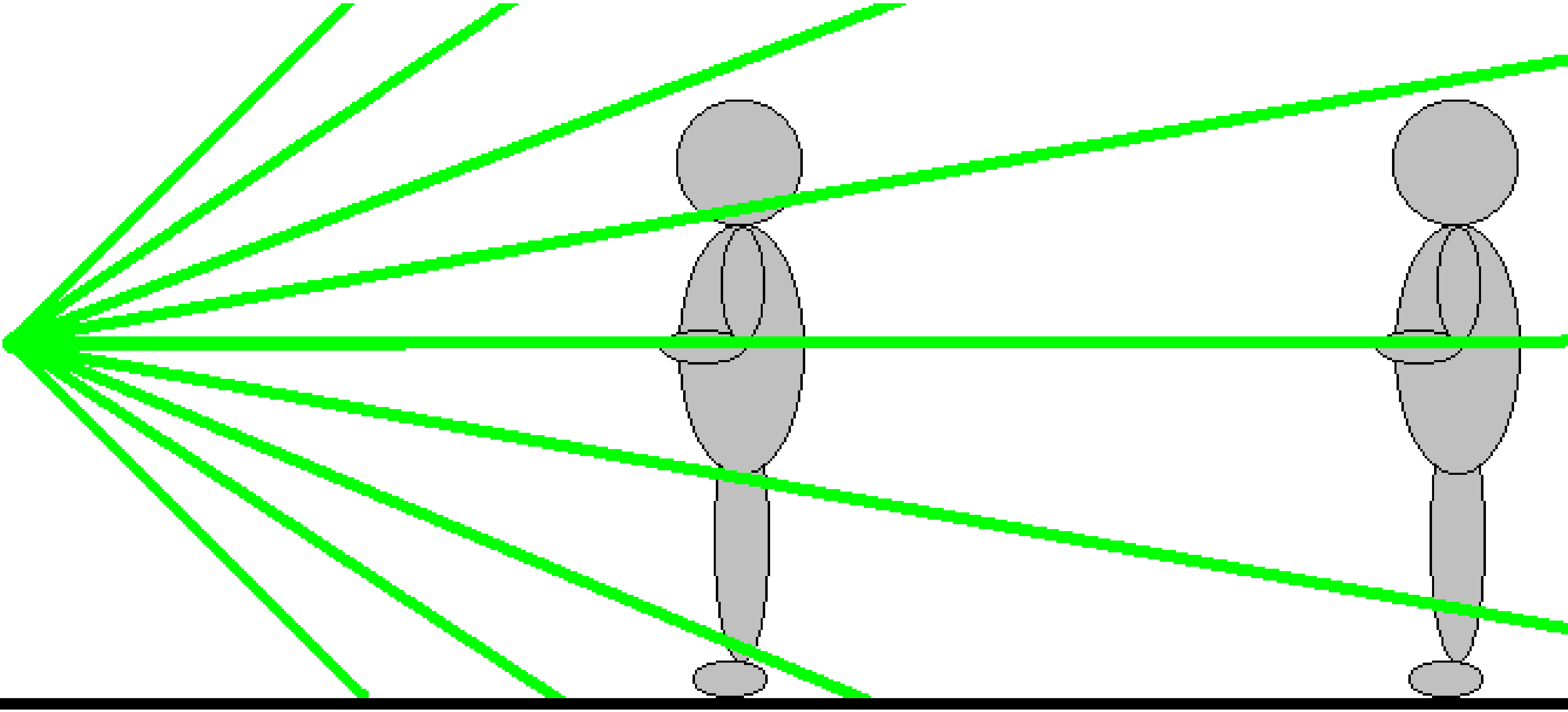
Shielding
Any material you can hide behind will reduce the dose. A specific material is required for each type of radiation. Concrete is good for all.

Try to avoid unnecessary exposition !



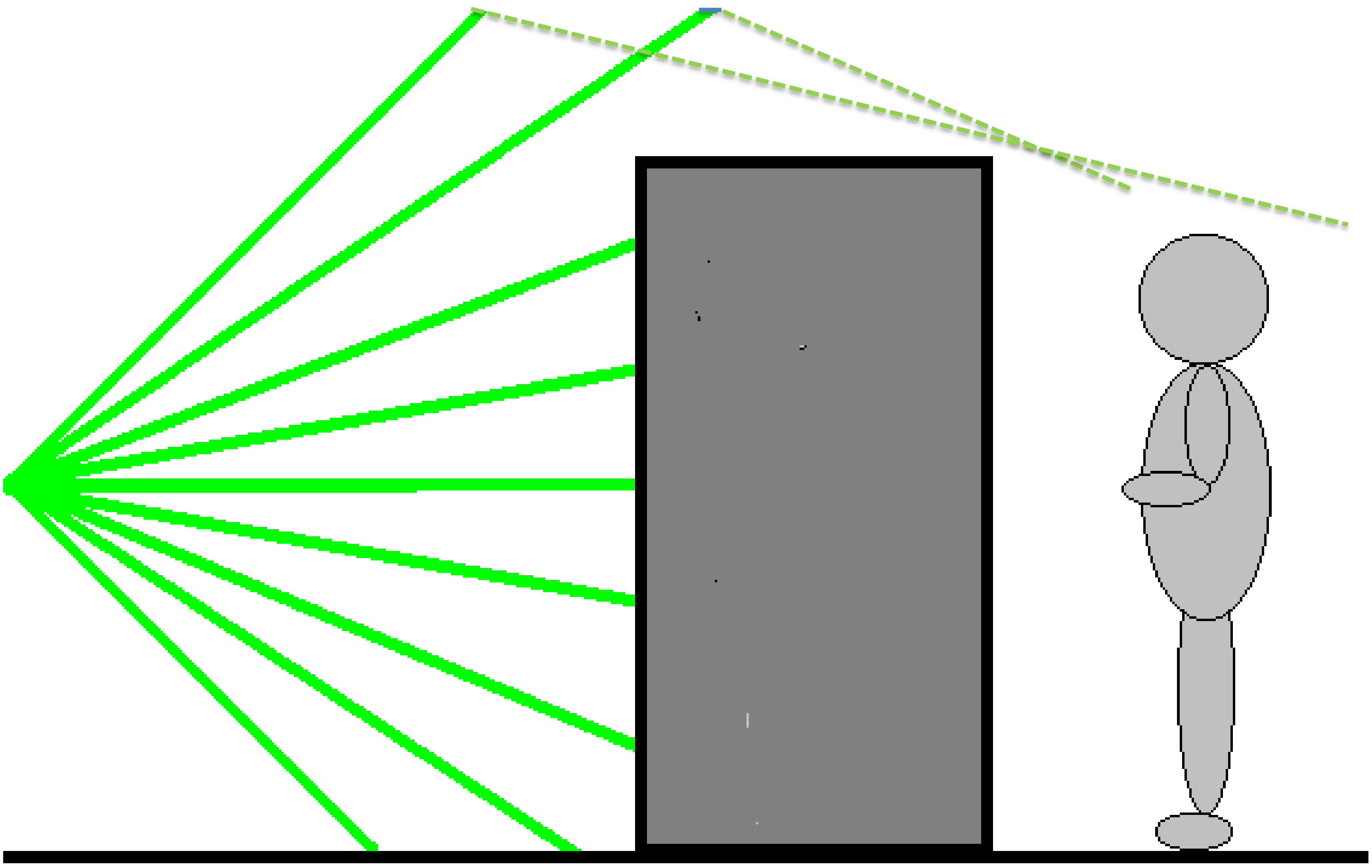


Distance



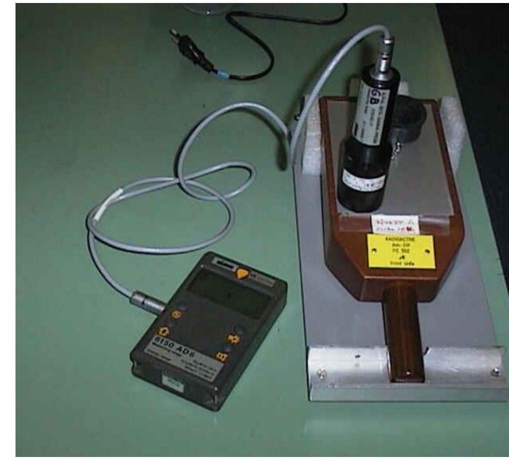
- Double distance = $^{1}/_{4}$ dose
- Triple distance = $^{1}/_{9}{}^{th}$ dose.

Shielding



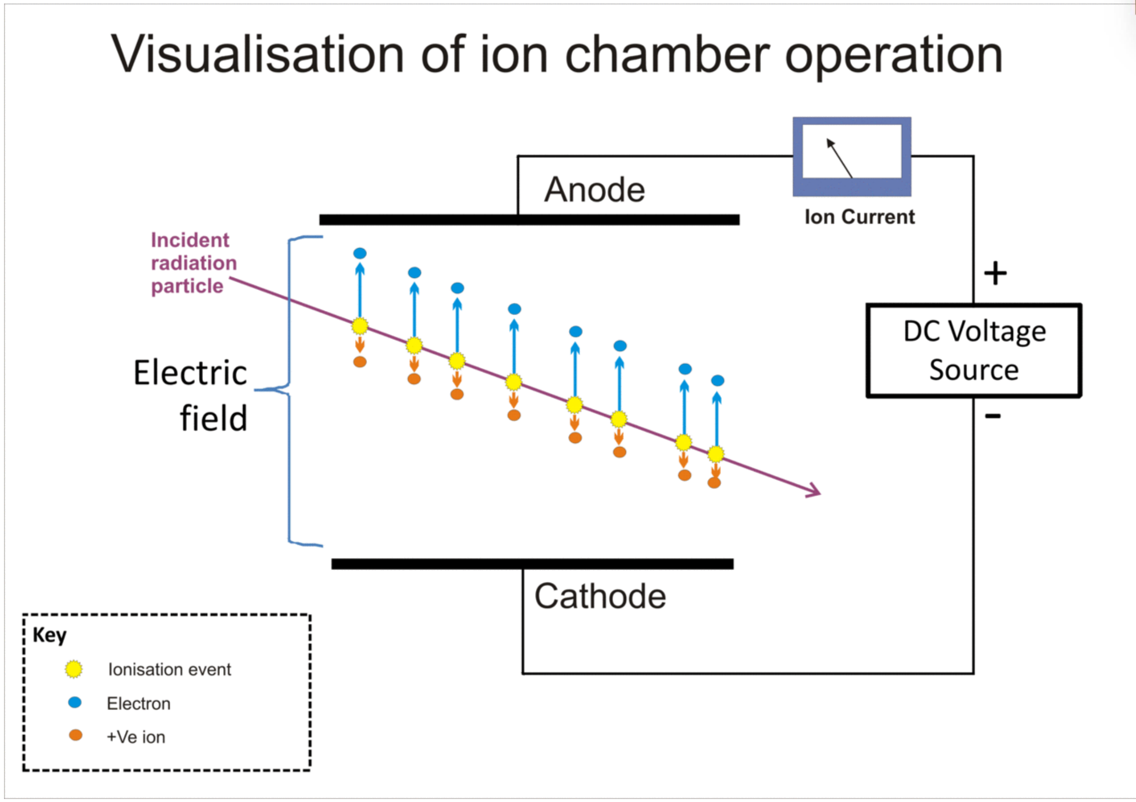
How to protect yourself : personal protective equipment

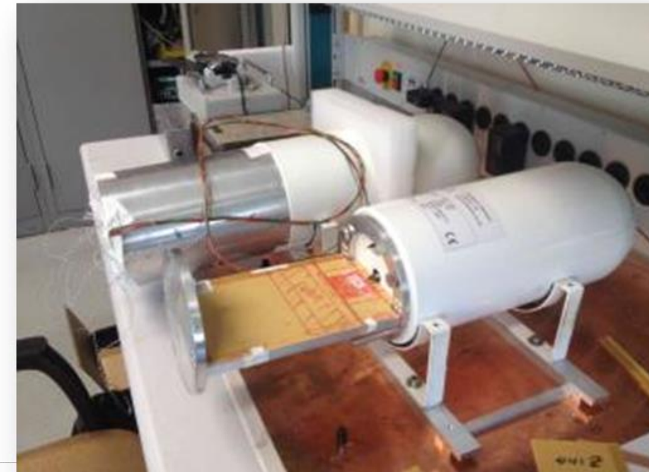
Radiation monitoring techniques and systems



Radiation monitoring techniques and systems

Ionisation chambers



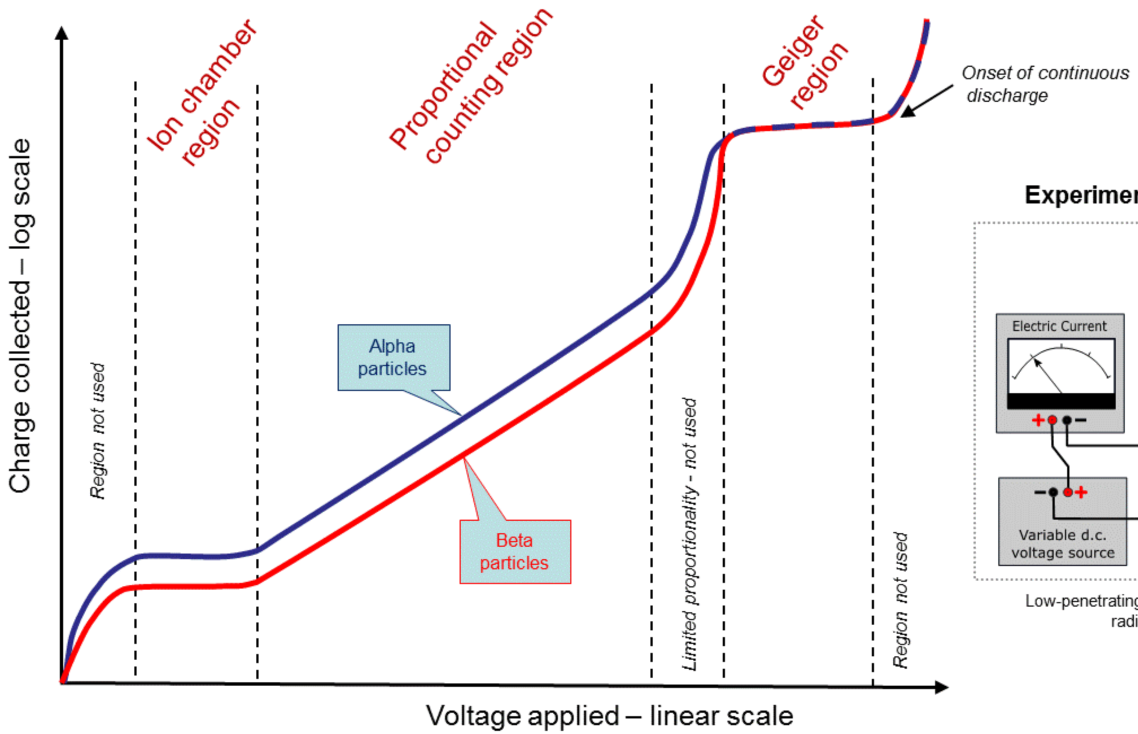


CROME Prototype

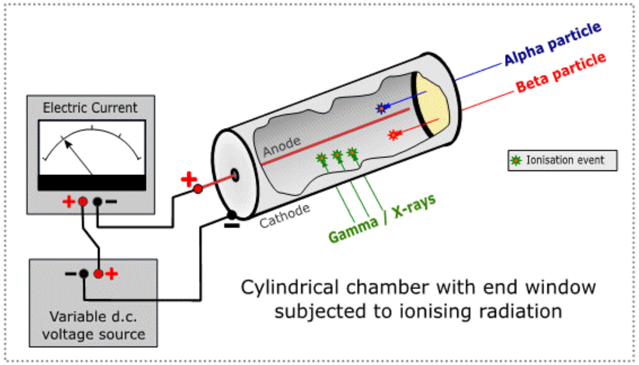
Practical Gaseous Ionisation Detection Regions

This diagram shows the relationship of the gaseous detection regions, using an experimental concept of applying a varying voltage to a cylindrical chamber which is subjected to ionising radiation. Alpha and beta particles are plotted to demonstrate the effect of different ionising energies, but the same principle extends to all forms of ionising radiation.
The ion chamber and proportional regions can operate at atmospheric pressure, and their output varies with radiation energy. However, in practice the Geiger region is operated at a reduced pressure (about 1/10th of an atmosphere) to allow operation at much lower voltages; otherwise impractically high voltages would be required. The Geiger region output does not differentiate between radiation energies.

Variation of ion pair charge with applied voltage



Experimental set-up of a cylindrical chamber

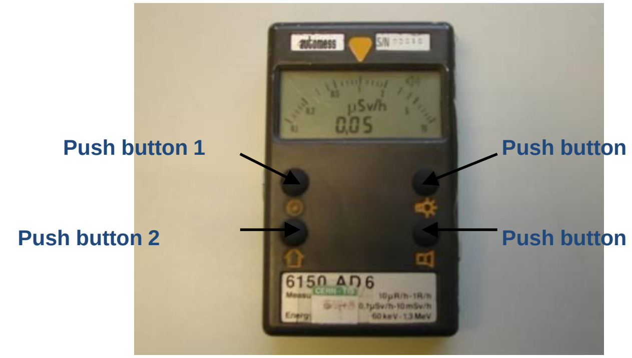


Low-penetrating radiation enters via an end window, but high-penetrating radiation can also enter via the cylinder side wall.

DS

Radiation protection instruments

Doserate meter 6150 AD6



Push Button 1 : on / off

Push Button 2 : mode :
doserate
doserate alarm
maximum doserate
intergrated doserate
dose alarm
battery check
Calibration parameters

Push Button 3 : backlight

Push Button 4 : speaker on / off

Detector : Geiger Müller counter

Range:
AD6 : 0,5 µSv/h to 10 mSv/h

Energy range :
AD6 : de 60 keV to 1,3 MeV

Dimensions : 130x80x29 mm

Mass: 400 grammes.
Alimentation : 9V standard battery.

Radiation protection instruments

Doserate meter 6150 AD6 with ADK

Surface contamination meter: used for alpha, beta, gamma rays.
Can measure surface contamination or is used to check clothes.

Detector : sealed proportional counter.
Active window of 2,75 mg/cm2.
Active surface of 100 cm2.

Counting mode: Alpha or Alpha, Beta, Gamma adjusted by the switch.
(remove protection plate).

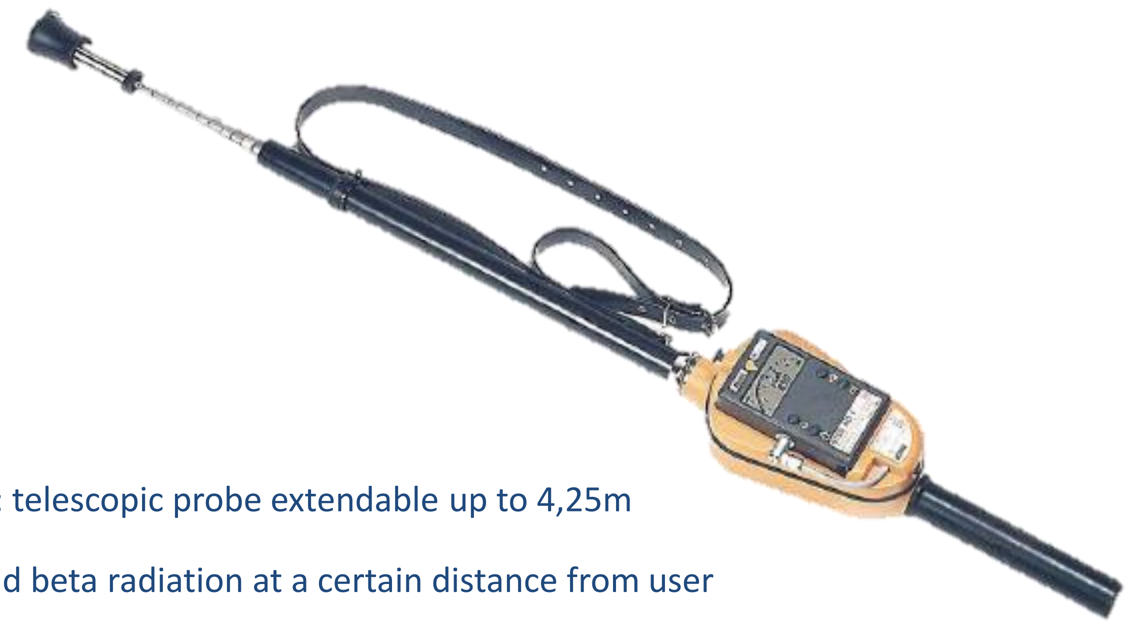
Cont rate: 1 to 999.000 cps.

Detection limits for 60Co : 0,4 Bq/cm2.

Efficiency:
90Sr / 90Y (Beta) : 53,5%
60Co (Beta) : 10,1% 60Co (Gamma) : 1,15%
137Cs (Beta) : 23% 137Cs (Gamma) : 0,22%

Radiation protection instruments

Doserate meter 6150 AD6 with Teletektor



Teletektor 6150 ADT: telescopic probe extendable up to 4,25m

Measures gamma and beta radiation at a certain distance from user

Detectors: 2 Geiger Müller counters : low doses at the end of the probe and high doses behind

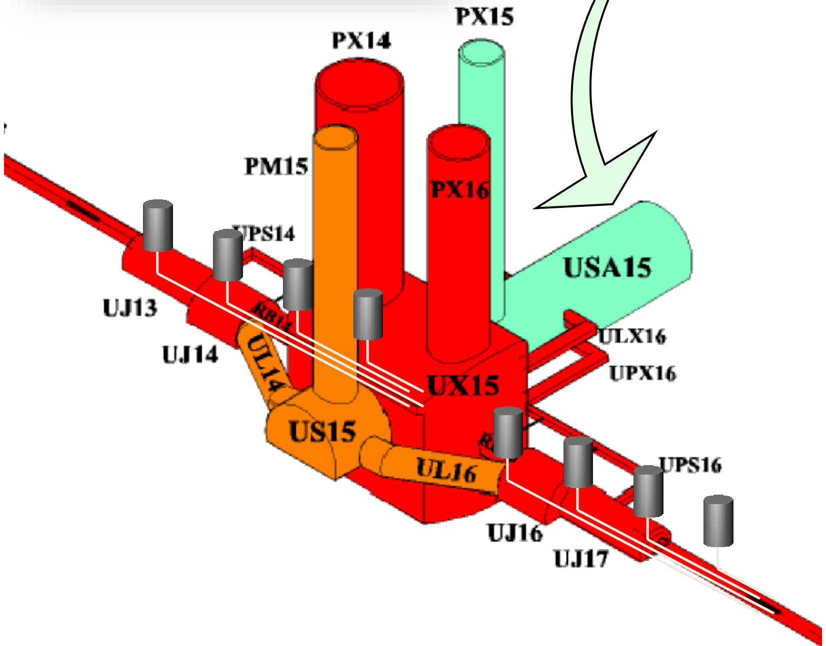
Doserates range: 0,5 µSv/h to 10 Sv/h

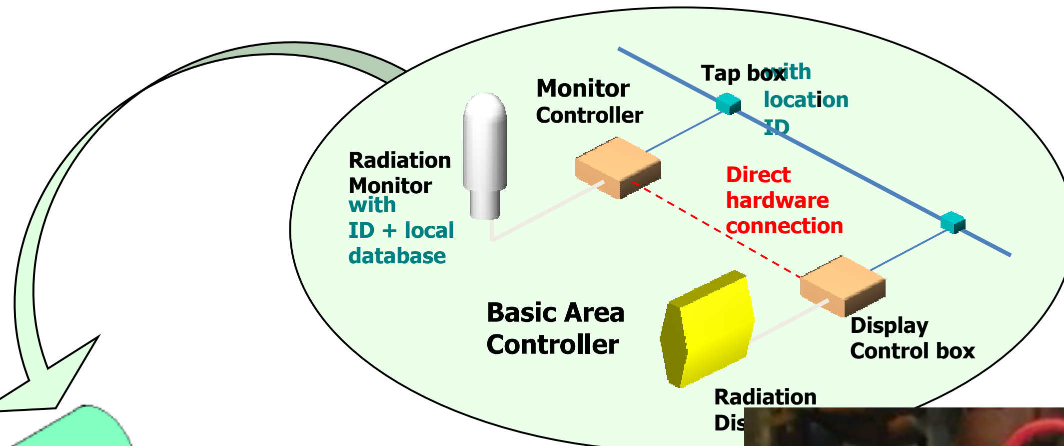
Energy range: 63 keV to 3 MeV

Dimensions : length from 92cm to 4,25m

Online monitoring of induced activity

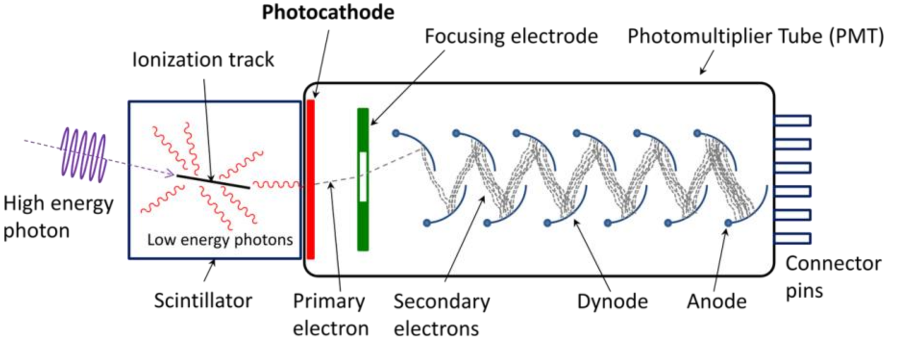
HSE
Occupational Health & Safety
and Environmental Protection Unit





Radiation protection instruments

Scintillators



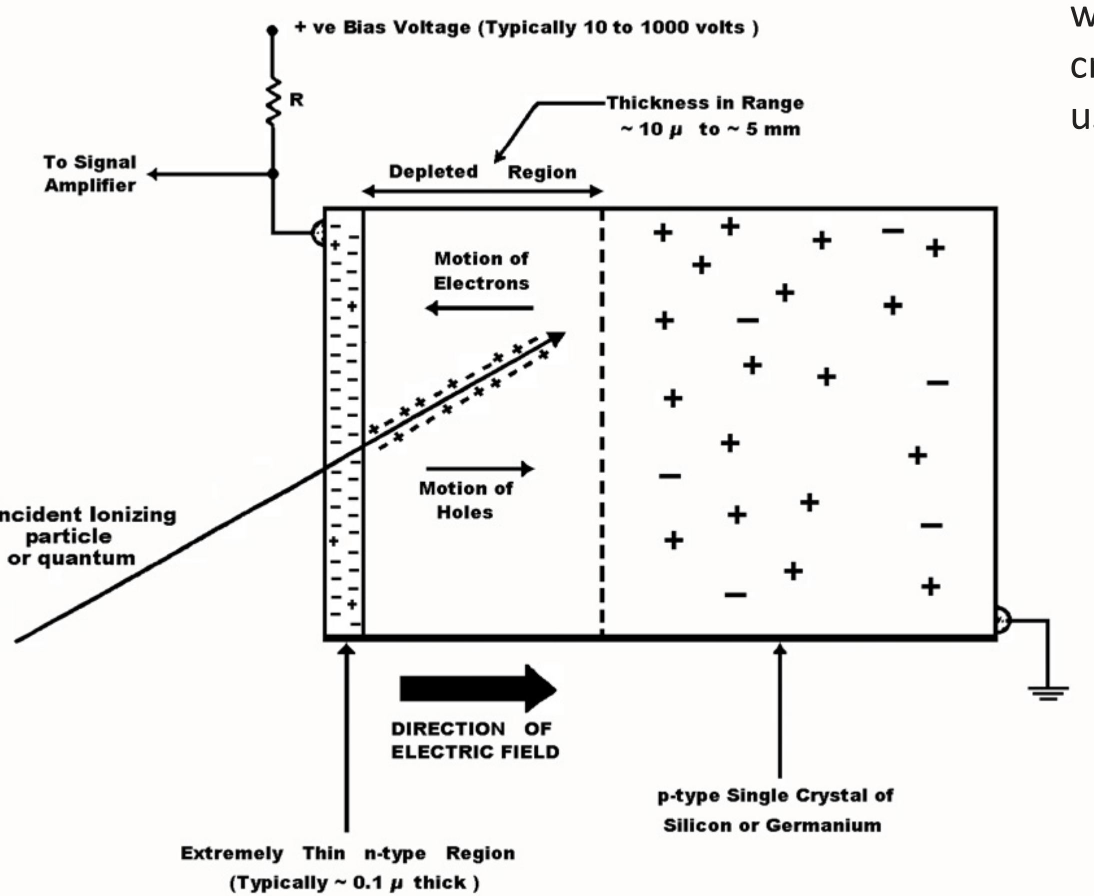
BGO scintillation detector

FHZ 512 BGO (bismuth germanate) – Z
Cs-137 => 1000 s-1/(µSv/h)
Am-241=> 3400 s-1/(µSv/h)
Co-60 =>550 s-1/(µSv/h)

Dimension and Weight ø 40 mm x 310 mm [ø 1.6” x 12.2”] / approx. 0.5 - 0.7 kg (1.1 - 1.5 lb)

Radiation protection instruments

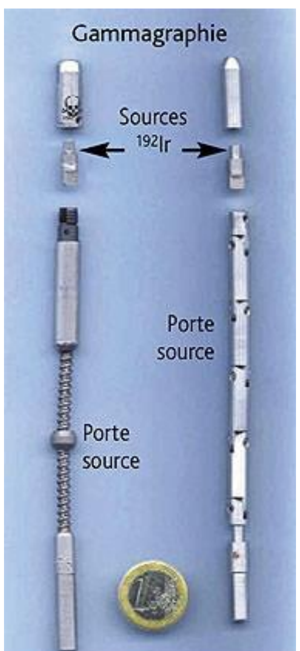
Semi conductors

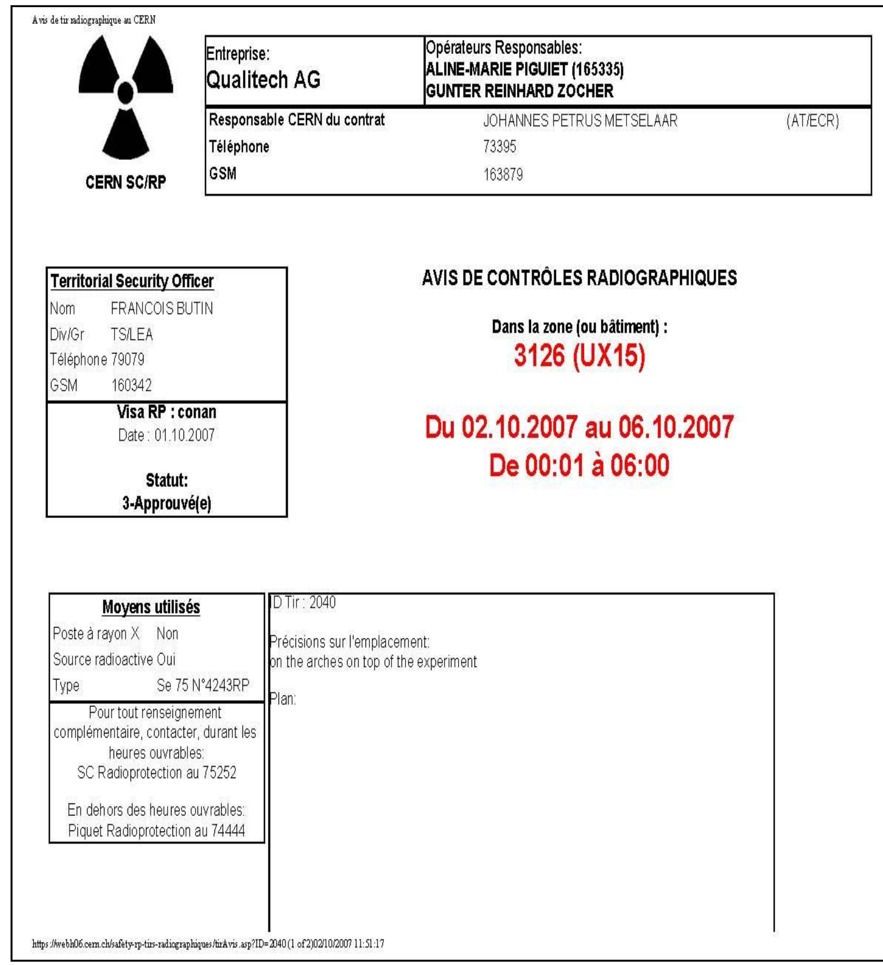


As a particle passes through the junction, the resultant excitation of electrons causes the formation of holes in the valence band. The electrons are then attracted to the *n* material, while the holes move toward the *p* material. This creates a current pulse which can be measured using a meter or counter.

Radioactive sources at CERN

Radiographies at CERN





Avis de tir radiographique au CERN

CERN SC/RP

Entreprise: Qualitech AG	Opérateurs Responsables: **ALINE-MARIE PIGUIET (165335)** **GUNTER REINHARD ZOCHER**	
Responsable CERN du contrat	JOHANNES PETRUS METSELAAR	(AT/ECR)
Téléphone	73395	
GSM	163879	

Territorial Security Officer

Nom	FRANCOIS BUTIN
Div/Gr	TS/LEA
Téléphone	79079
GSM	160342

Visa RP : conan
Date : 01.10.2007

Statut:
3-Approuvé(e)

AVIS DE CONTRÔLES RADIOGRAPHIQUES

Dans la zone (ou bâtiment) :
3126 (UX15)

Du 02.10.2007 au 06.10.2007
De 00:01 à 06:00

Moyens utilisés

Poste à rayon X	Non
Source radioactive	Oui
Type	Se 75 N°4243RP

Pour tout renseignement complémentaire, contacter, durant les heures ouvrables:
SC Radioprotection au 75252

En dehors des heures ouvrables:
Piquet Radioprotection au 74444

ID Tir : 2040

Précisions sur l'emplacement:
on the arches on top of the experiment

Plan:

https://webh06.cern.ch/safety-rp-tirs-radiographiques/tirAvis.asp?ID=2040 (1 of 2)02/10/2007 11:51:17

Conclusion

- ✓ Whatever the source, radioactivity is potentially harmful for your health and must be considered carefully.
- ✓ Keep in mind : time, distance, shielding.
- ✓ The goal in every mission is to reduce the doses as much as possible. Follow the ALARA principle.

And now you are….

HSE
Occupational Health & Safety
and Environmental Protection Unit

e Carbonez

CERN

HSE
Occupational Health & Safety
and Environmental Protection Unit

Don’t forget to read your dosimeter

CERN Dosimetry Service

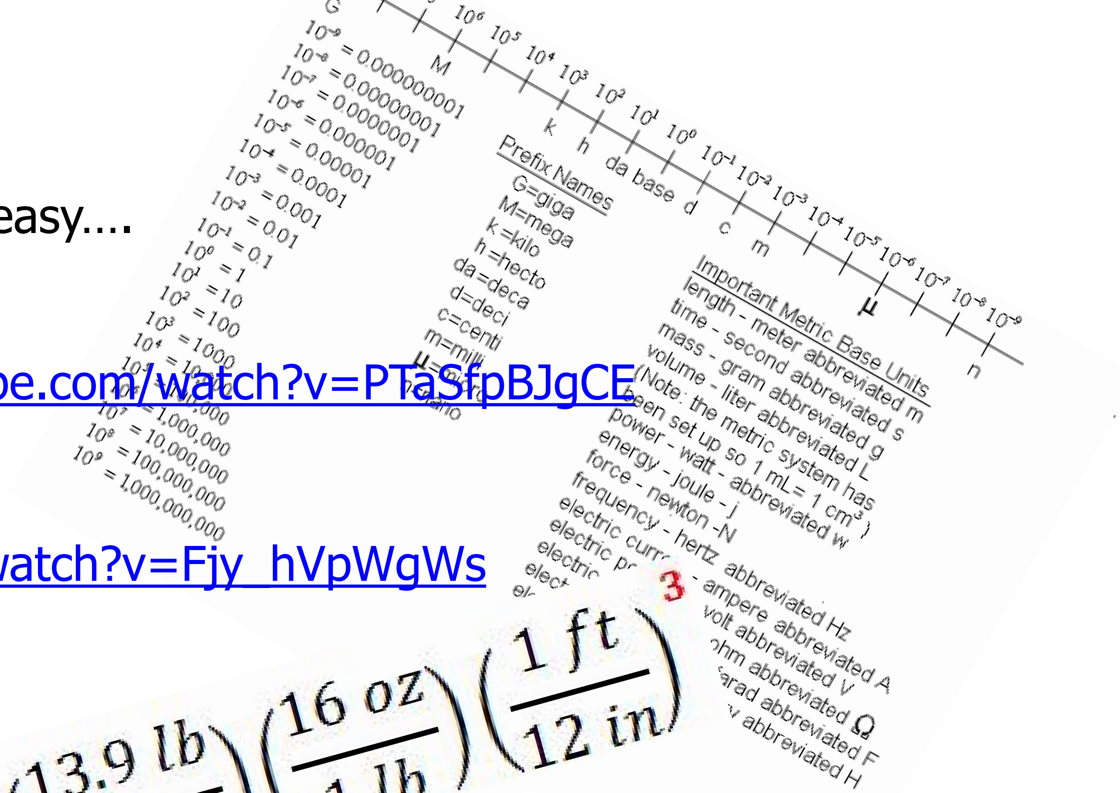
THANK YOU

CERN

Units conversion… made easy….

http://www.youtube.com/watch?v=PTaSfpBJgCE

http://www.youtube.com/watch?v=Fjy_hVpWgWs



$$\left(\frac{13.9\ lb}{ft^3}\right)\left(\frac{16\ oz}{1\ lb}\right)\left(\frac{1\ ft}{12\ in}\right)^3$$

```
static void Main(string[] args)
{
    string Fahrenheit = string.Empty;
    Fahrenheit = Units.Temperature.Convert(25.5,
        Temperature.Celcius,
        Temperature.Fahrenheit).ToString();
}
```