Fundamentals of radiation protection

Introduction

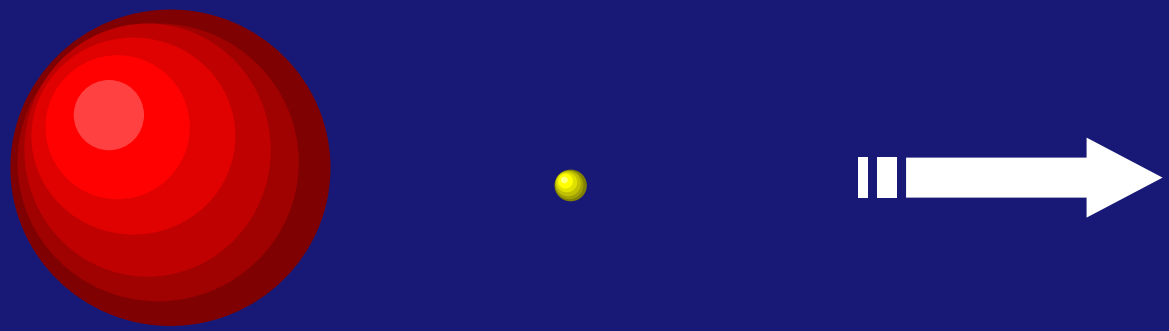
- Radioactivity and radiation
  - Definitions
  - Dose quantities / units
- Radiation protection
- Effects of ionising radiation

Radiation

The term radiation is broad and may include light, radio waves, etc.

- Here it describes ionising radiation
- Alpha particles, beta particles and gamma rays

Natural and artificial sources



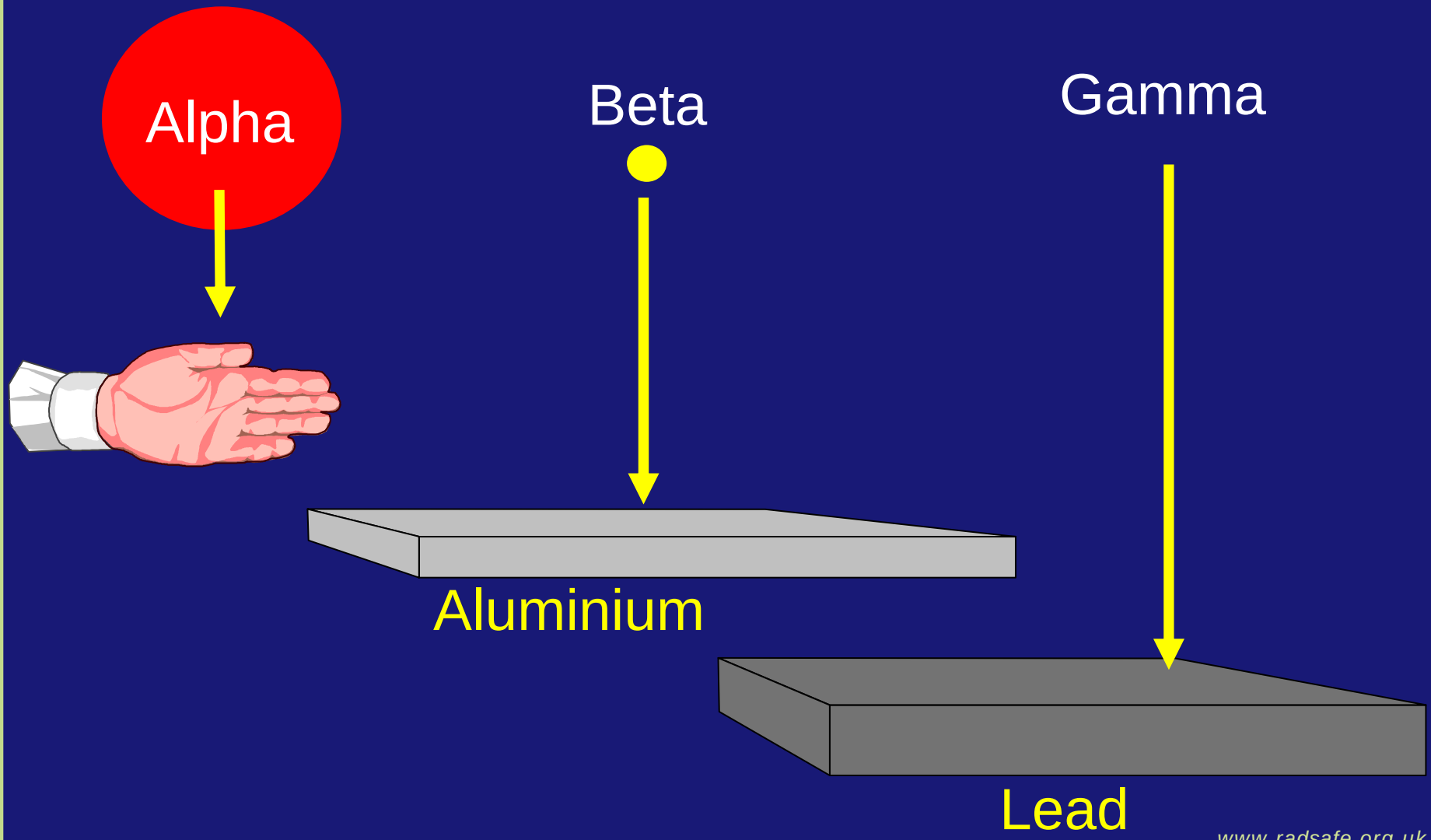
Radioactivity

This describes the property of some materials to emit ionising radiation

- Unstable atoms ‘decay’ into stable forms, giving out radiation in the process
- The path to stability may take only one or many such transformations

Lead-210 ➡ Bismuth-210 ➡ Polonium-210 ➡ Lead-206

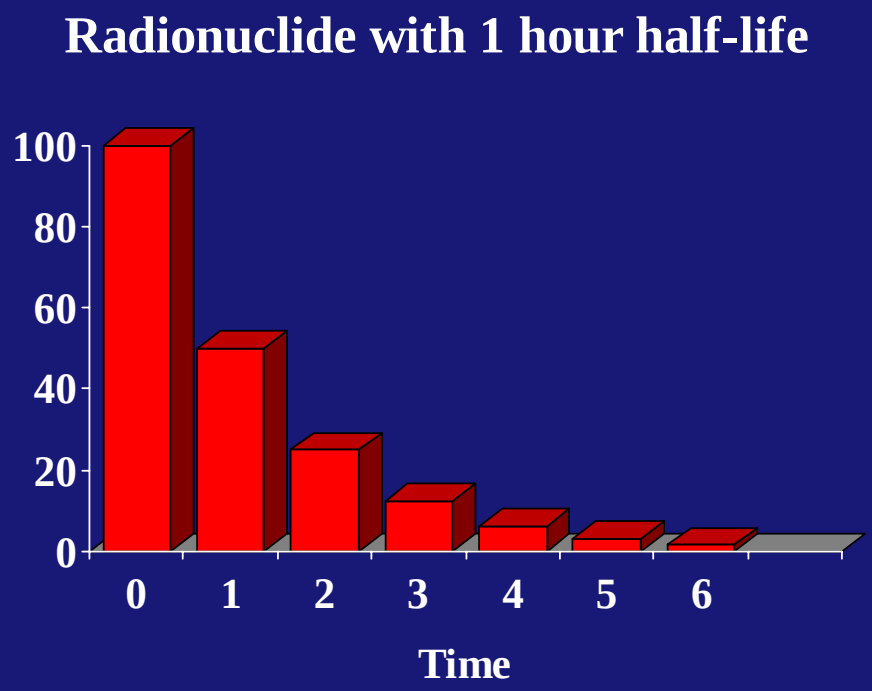
Penetrating Powers



Half Lives

The time taken for the activity of a radionuclide to fall to half its original value

- This is a characteristic of the radionuclide and tells us how fast or slow it will decay



Activity

A measure of radioactivity

- Determined by the number of spontaneous transformations occurring each second
- Expressed in a unit called the *becquerel* (Bq)

- *For example, 1 gram of Pu-239 has an activity of approximately 2,000 MBq - that is to say it emits about 2,000 million alpha particles each second!*

What is a Becquerel?

• Loaf of bread	70 Bq
• Coffee (1 kg)	1,000 Bq
• An adult	4,800 Bq
• Cornish granite (10 kg)	12,000 Bq
• 1 tonne of uranium	10 billion Bq

"Radioactive substance" definition

Dose Quantities

- Absorbed Dose
  Amount of energy deposited
- Equivalent Dose
  Weighted to account for the different types of radiation
- Effective Dose
  Weighted to account for the different sensitivities of organs

Units

Quantity	Unit (Symbol)
Activity	becquerel (Bq)
Absorbed dose	gray (Gy)
Equivalent dose	sievert (Sv)
Effective dose	sievert (Sv)

Prefixes

Activity (Bq)

- Mega (M) = 10^6 = 1,000,000
- Giga (G) = 10^9 = 1,000,000,000
- Tera (T) = 10^{12} = 1,000,000,000,000

- 1TBq = 1,000 GBq = 1,000,000MBq

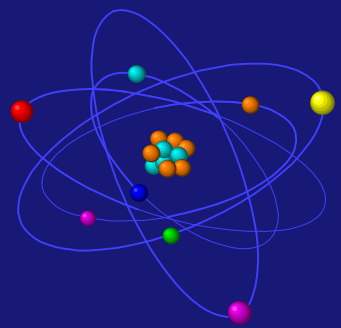
Dose (Sv)

- milli = (m) = 10^{-3} = 0.001
- micro = (μ) = 10^{-6} = 0.000,001

- 1 Sv = 1,000 mSv = 1,000,000 μSv

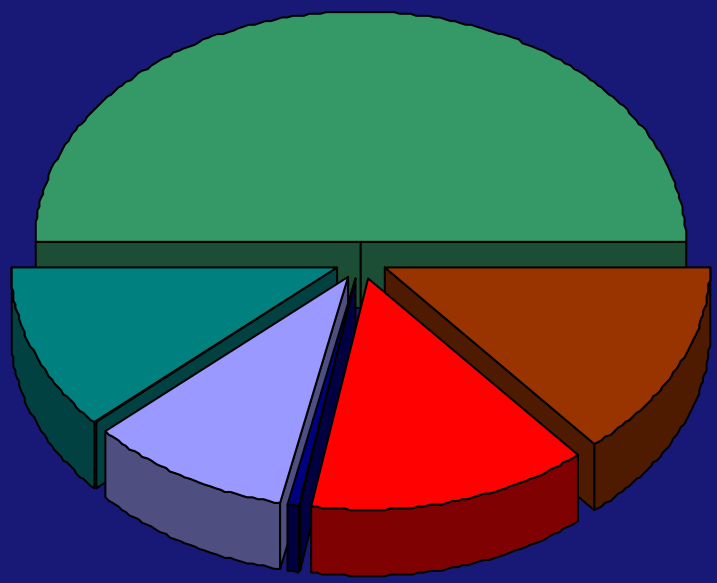
Example Doses

- Chest X-ray : 0.02 mSv
  (20 µSv)
- Flight to New York : 0.042 mSv
  (42 µSv)
- UK annual average exposure : 2.6 mSv
  (2600 µSv)



Sources of Exposure

Miscellaneous
Products 0.05%
Discharges 0.05%
Fallout 0.1%
Occupational 0.3%



Radiation Protection

Radiation Protecting - External Hazard

- Time
  - dose = dose rate x time
- Distance
  - inverse square law
- Shielding
  - penetrative powers of different radiations

Contamination

This is the escape and spread of radioactive material

- Contact with radiation cannot normally make non-active substances radioactive
- Materials can apparently become 'radioactive' if they are contaminated by radioactive material

Radiation Protection - Contamination Hazards

Prevent possible intakes of material

- Inhalation, ingestion, skin absorption, wounds

Avoid contamination of skin

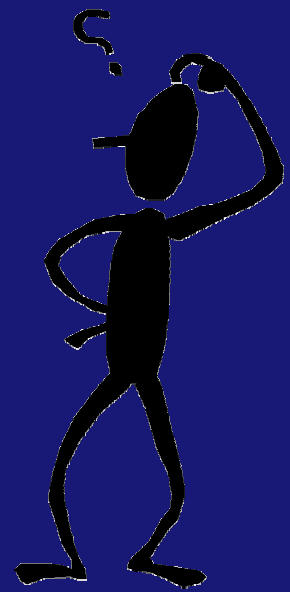
- Learn to ‘dress and undress’ properly
- Master the change barrier procedure
- Don’t touch!
- Protect cuts and abrasions

Effects of ionising radiation

Important Factors

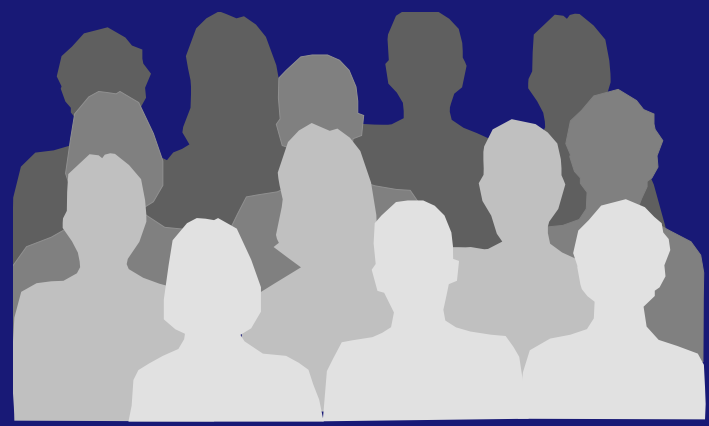
The biological effect will depend on:

- Type of radiation
- Total dose
- Dose rate
- Total area exposed
- Radiosensitivity of the tissue or organ



Biological Effects

- Early injuries (Deterministic)
- Late effects (Stochastic)
  - Malignant disease
  - Hereditary defects



Acute Radiation Syndromes

1 Gy +

- Prodromal
- Central nervous system
- Gastrointestinal

- Haematological
- Bone marrow

Localised Exposures

Early or deterministic effects	Approximate absorbed dose
Localised exposures	
Erythema	5 Gy+
Temporary hair loss	4 Gy+
Permanent hair loss	7 Gy+
Skin burns	20 Gy+
Skin necrosis	50 Gy+

Late Effects

- Probability of an effect is proportional to dose received (stochastic)
- No thresholds!

- Cancer and hereditary defects
  - EC citizens currently have a risk of about 25% of dying of cancer

Radiological Risks

Radiological risk	Dose (mSv)	Risk of Death
Living in Cornwall	7.8	1 in 3,200
Brain scan	5	1 in 5,000
Average annual	2.6	1 in 10,000
Radon	1	1 in 25,000
Chernobyl	0.046	1 in 500,000
Chest X-ray	0.02	1 in 1.25 million
135 g brazil nuts	0.01	1 in 2.5 million

Non-radiological Risks

Other risks	Risk of Death
Heart disease	1 in 200
Cancer	1 in 400
Smoking	1 in 1,000
(10 a day)	(1 in 200)
Road accident	1 in 6,000
Domestic accident	1 in 10,000
Industrial accident	1 in 20,000
Drowning	1 in 30,000
Poisoning	1 in 100,000
Lightning strike	1 in 2,000,000