Ionising Radiation Detection & Measurement

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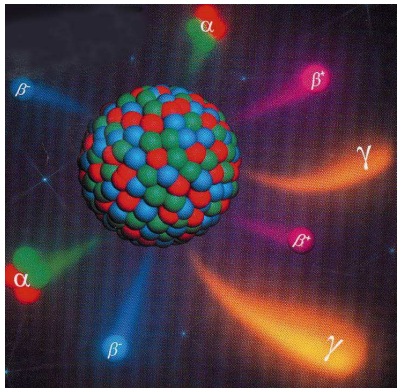
Ionising Radiation Detection & Measurement

- Introduction
  - Matter ?
  - Interaction Radiation – Matter
- Detector Types
  - Ionisation Chamber
  - Scintillation detectors
- Measurement of Radiation
- Dosimetry



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Introduction

If it is Green or Wriggles, it is
Biology

- If it Stinks, it is
Chemistry

If it makes a lot of noise, it is
Mechanics

If it does not work, it is
Physics

Detection of radiation ?

- Radiation cannot be detected directly !
- The consequences of the interaction between radiation and matter can be detected
  - Ionisation
  - Excitation

Matter = Atoms

Protons

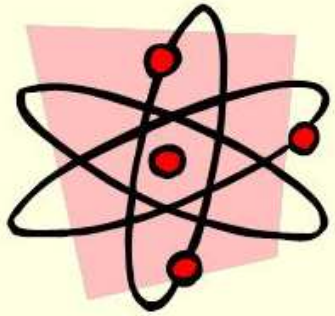
- Found in the **nucleus** of atom
- **positive (+) charge**
- Mass Value ≈ **1**

Neutrons

- found in **nucleus** of atom
- **neutral (no) charge**
- Mass value ≈ **1**

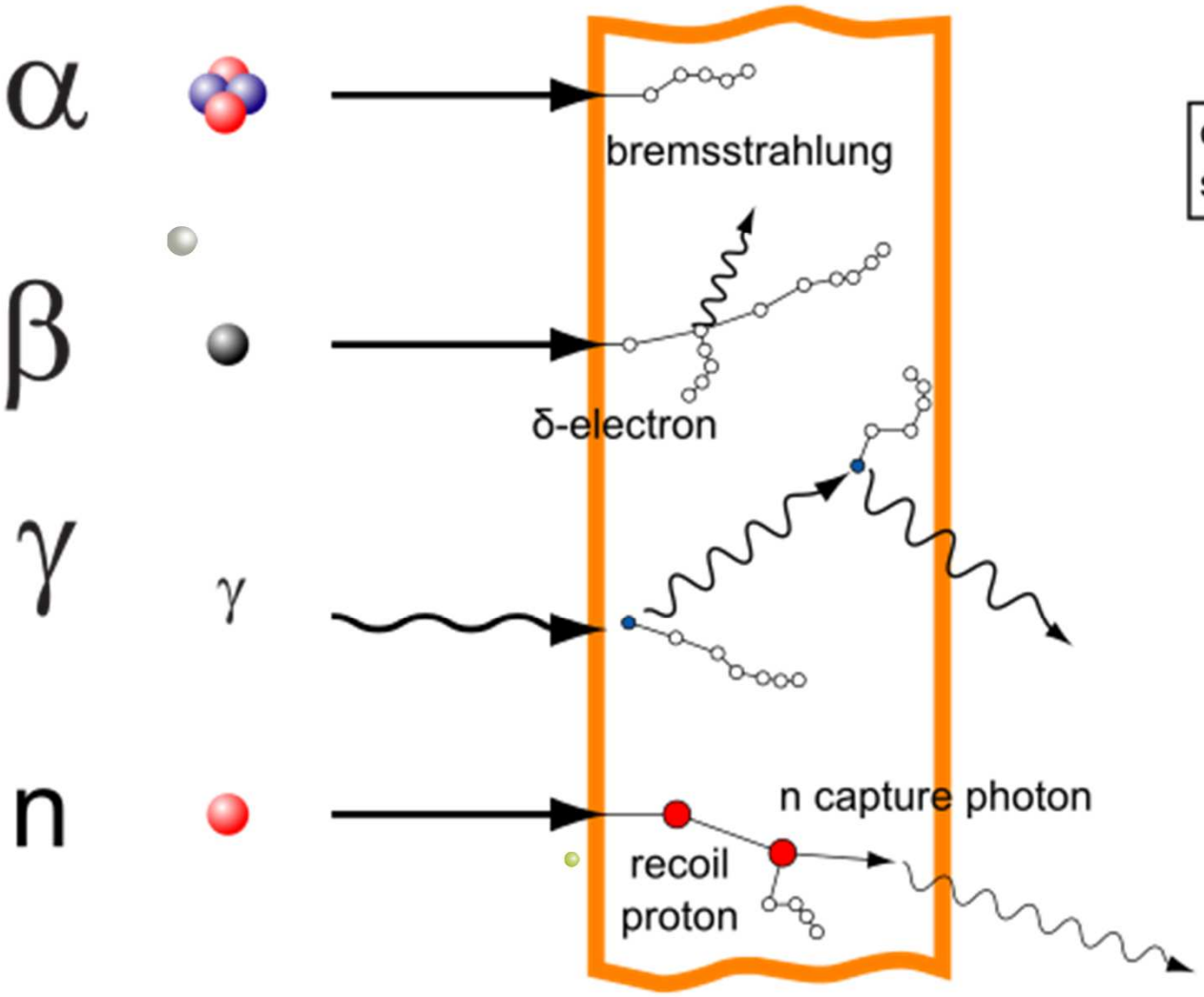
Electrons

- found in **clouds orbiting around nucleus**
- **negative (-) charge**
- Mass value ≈ **0**



- Dimensions
  - Atom : 60 to 270 E^{-12} m
  - Nucleus: 2 to 15 E^{-15} m (~ 20 000 times smaller than atom)

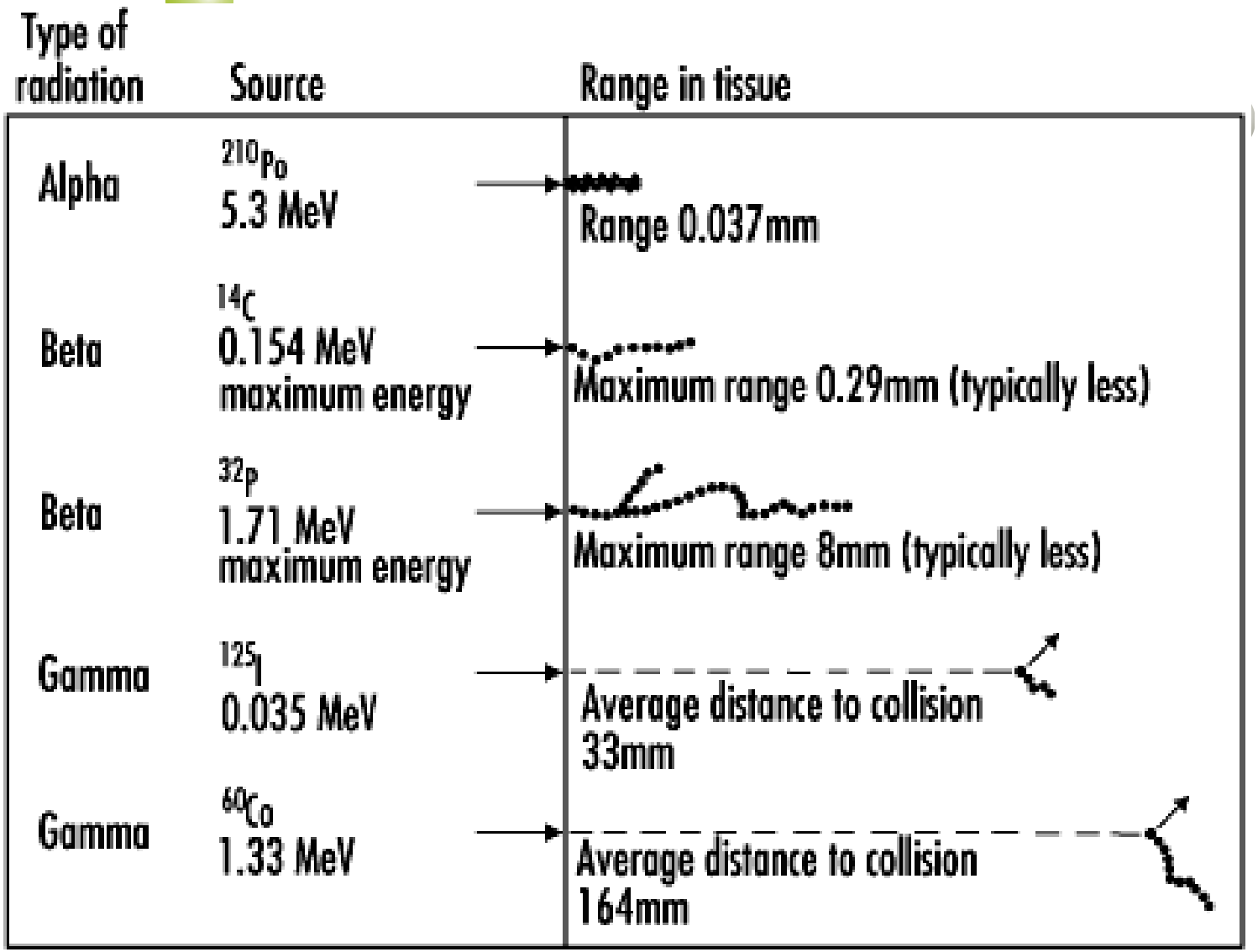
Interaction of ionizing radiation with matter



charged particles interact strongly and ionize directly

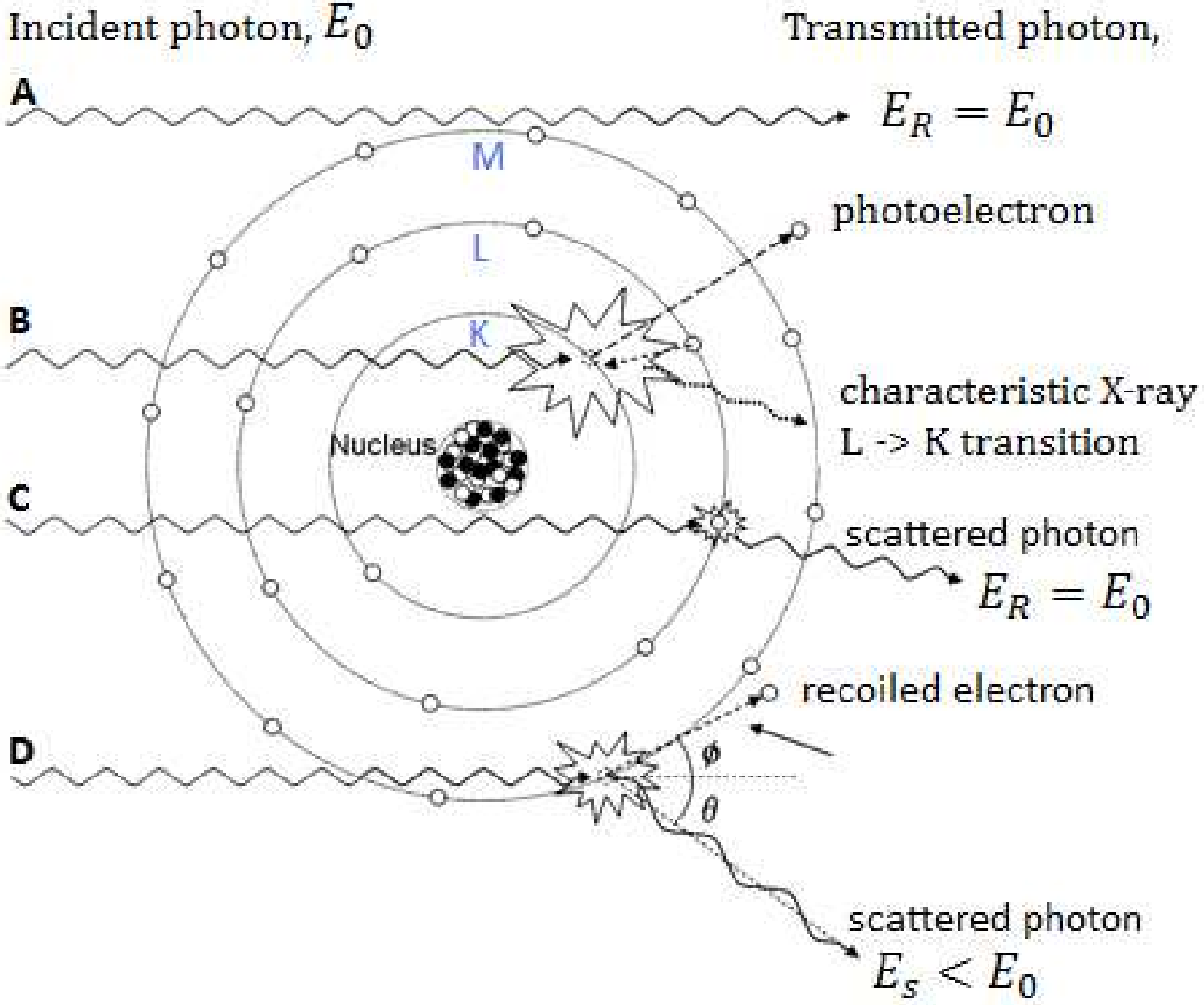
neutral particles interact less, ionize indirectly and penetrate farther

Typical Range of Radiation in Tissue



Source: Shapiro 1972.

Interaction of γ-Radiation with Matter



A. TRANSMITTED UNAFFECTED
No interaction

B. PHOTOELECTRIC ABSORPTION
Collision with a tightly bound inner-shell electron

C. RAYLEIGH SCATTERING
Elastic collision with a bound outer-shell electron

D. COMPTON SCATTERING
Inelastic collision with weakly bound outer-shell electron

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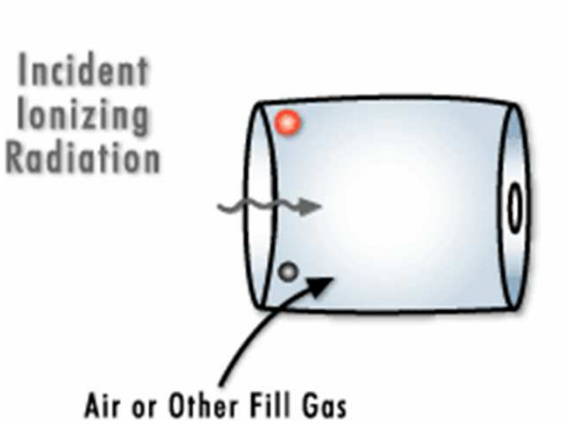
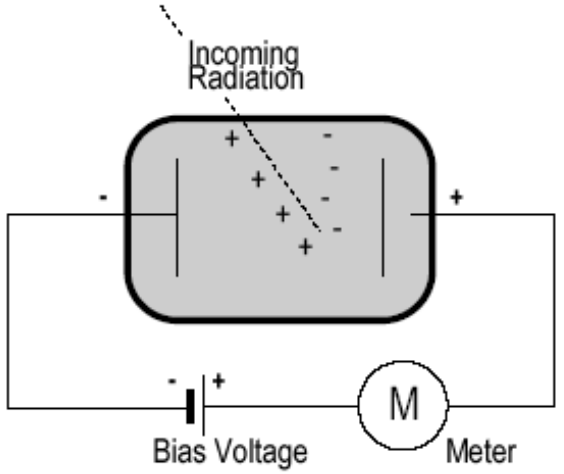
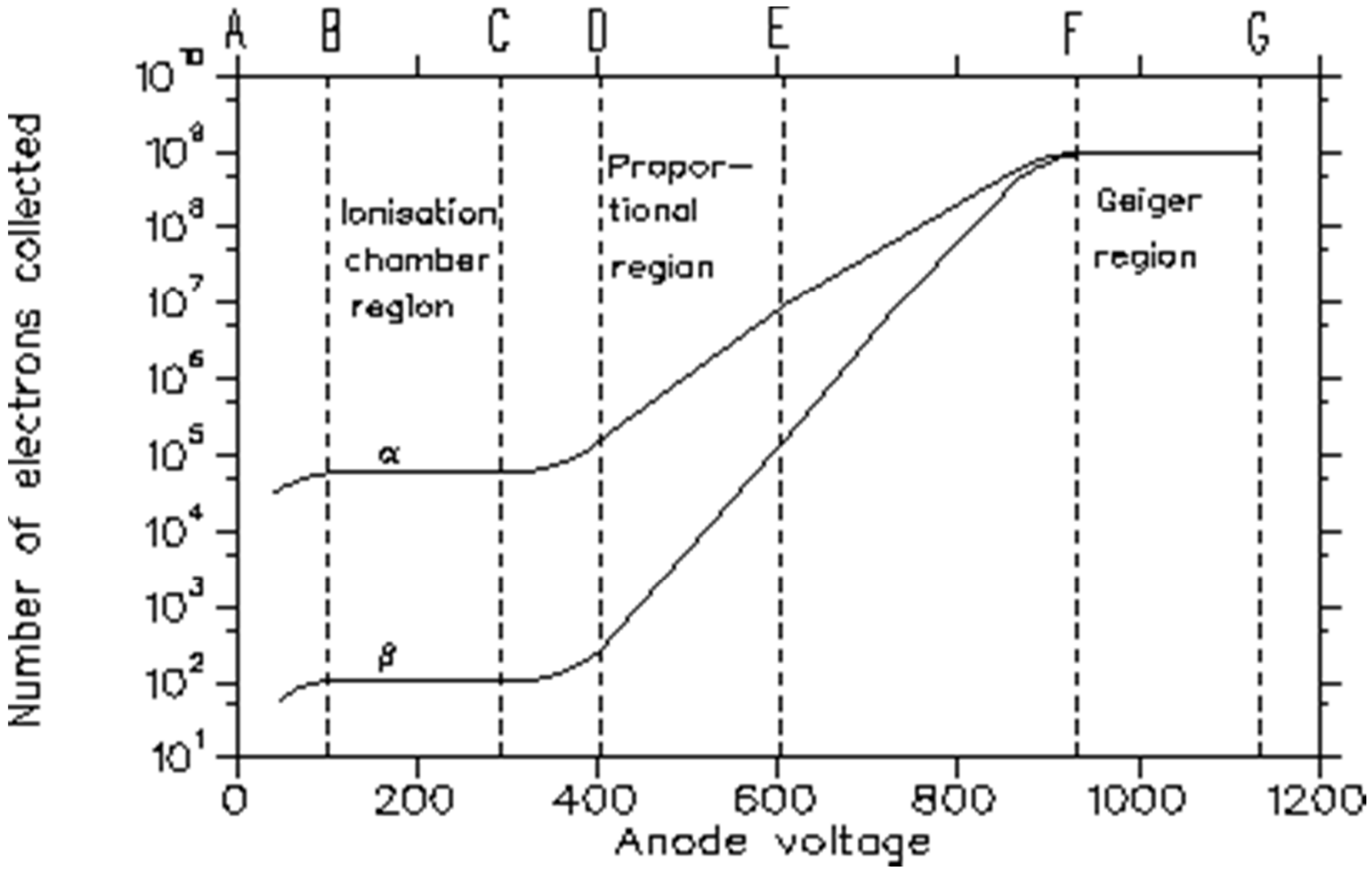
Ionisation Chamber - Principle

- Gas-Filled Chamber
- 2 electrodes
- Ionisation of the gas (creation of charges)
- Behaviour of the Chamber depends on :
  - Composition of the gas
  - Gas pressure
  - Electric field across the electrodes
  - How the created charges are collected



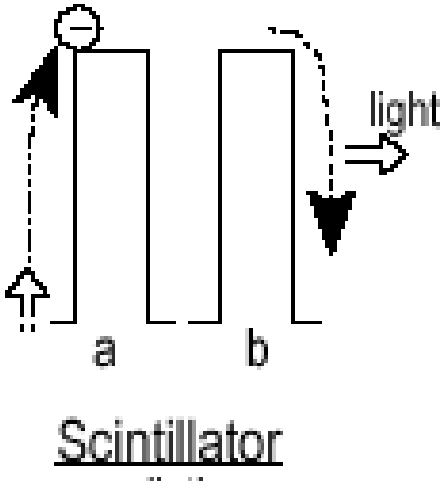


Ionisaton Chamber – Electric Field



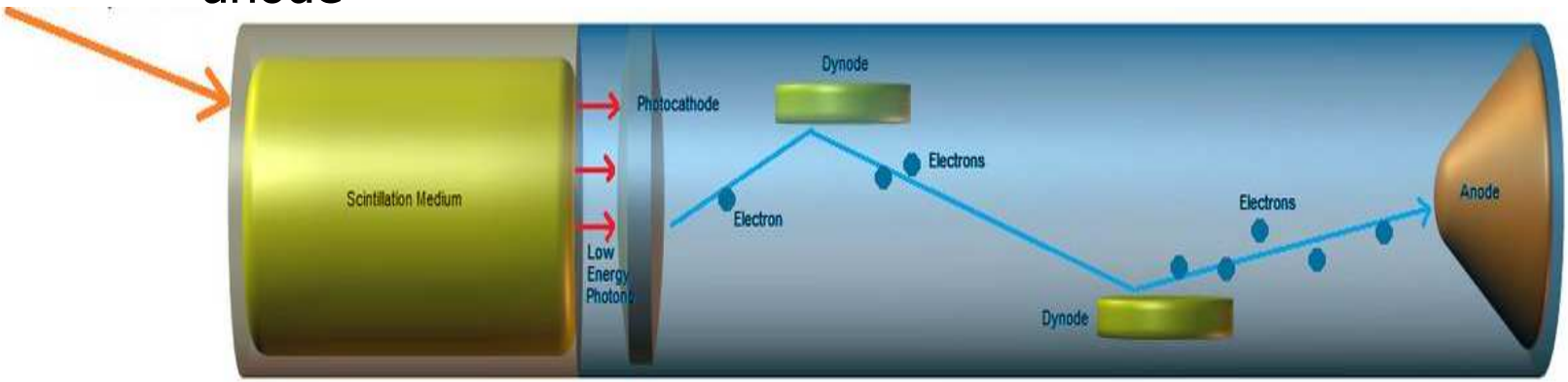
Scintillation Detector

- Based on excitation of electrons (Compton en photo-elektric effect)
- De-excitation of excited electron provides a pulse of light
- Pulse of light is amplified in a photomultiplier tube to provide an electric signal
- Signal is proportional with the energy of incoming photon, and hence can be used for spectrometry



NaI(Tl) Scintillator

- Photon excites scintillation material
- De-excitation of electron to lower energy and emission of a light pluse
- Licht pulse captured on photocathode and produces 1 or more electrons
- Acceleration and multiplication of electrons by a series of dynodes to create an electric pluse that is captured on the anode



Detecting Radiation ≠ Measuring Radiation

- **Detector Efficiency**
  - Not all emitted radiation is detected: radiation needs to hit the detector
  - Not every particle or photon wil interact with the detector
  - Energy Dependancy
    - Energy compensated GM-tubes

$$\varepsilon_{abs} = \frac{\#\ detected\ events}{\#\ emitted\ events}$$

"Background"-Radiation

- Cosmic Radiation
- Other natural radiation sources
- Other nearby radioactive sources

- Detector Shielding
- Evaluate & Take into account background

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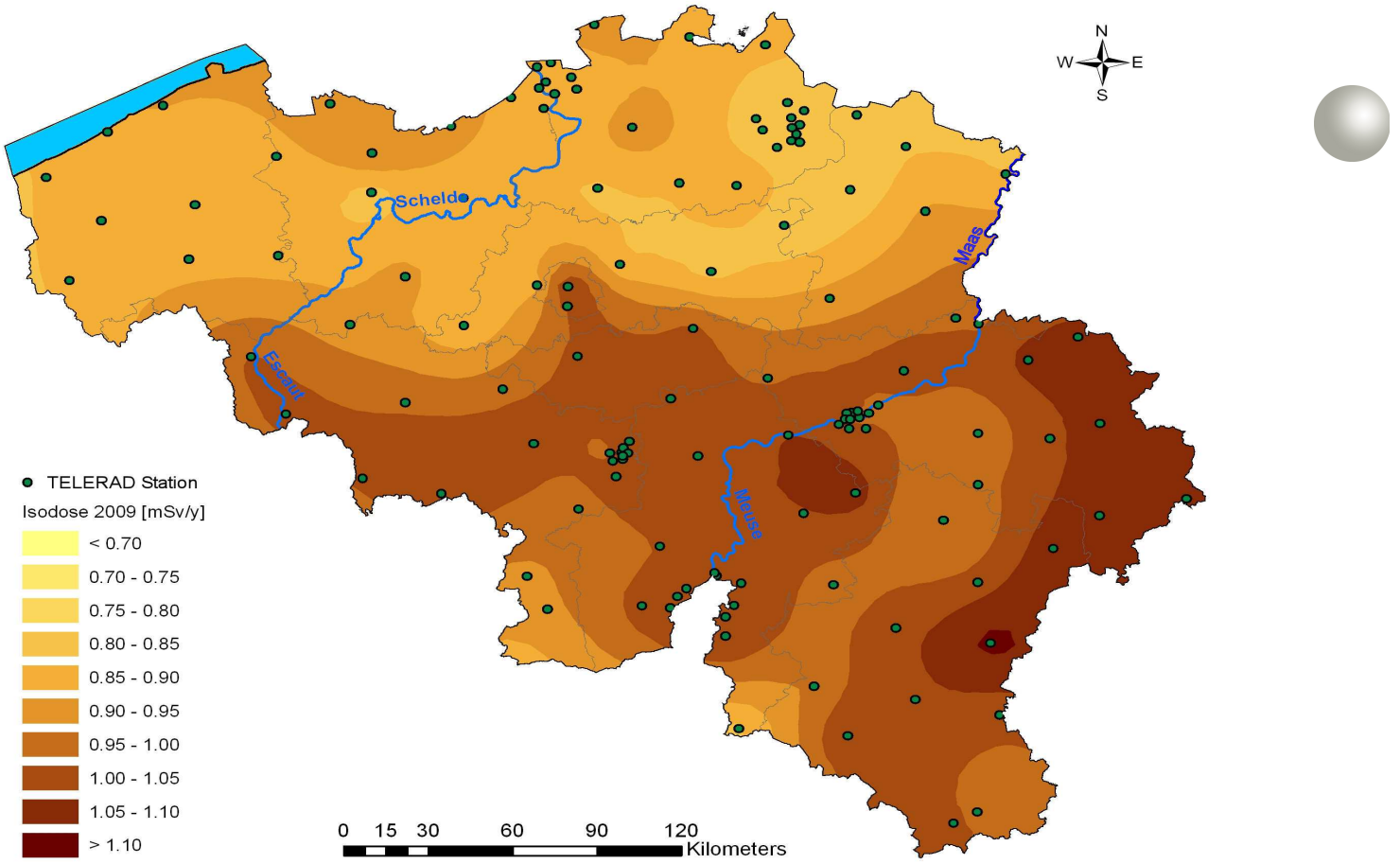
Dose Rate in Belgium from Natural Radiation



From 60 to 130 nSv/h depending on the region

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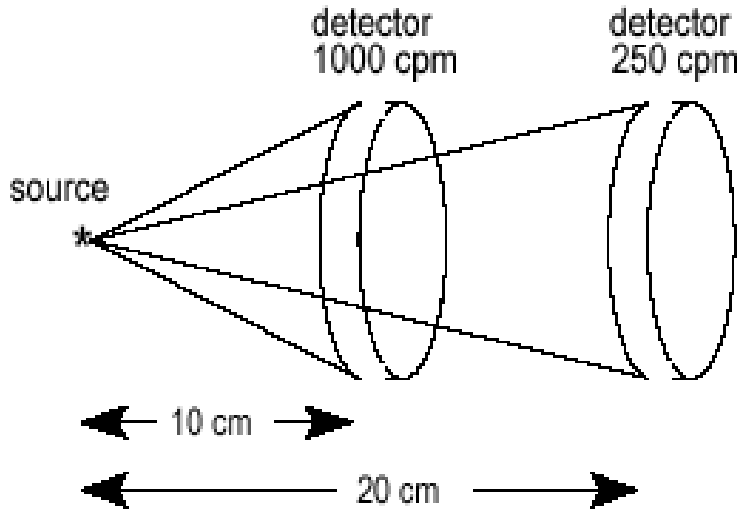
Other factors that can influence measurements

- Geometry between source and detector
- Nearby absorbing or reflecting materials
- R^2-law
- Self Absorption of the source
- Reflecting material on the detector



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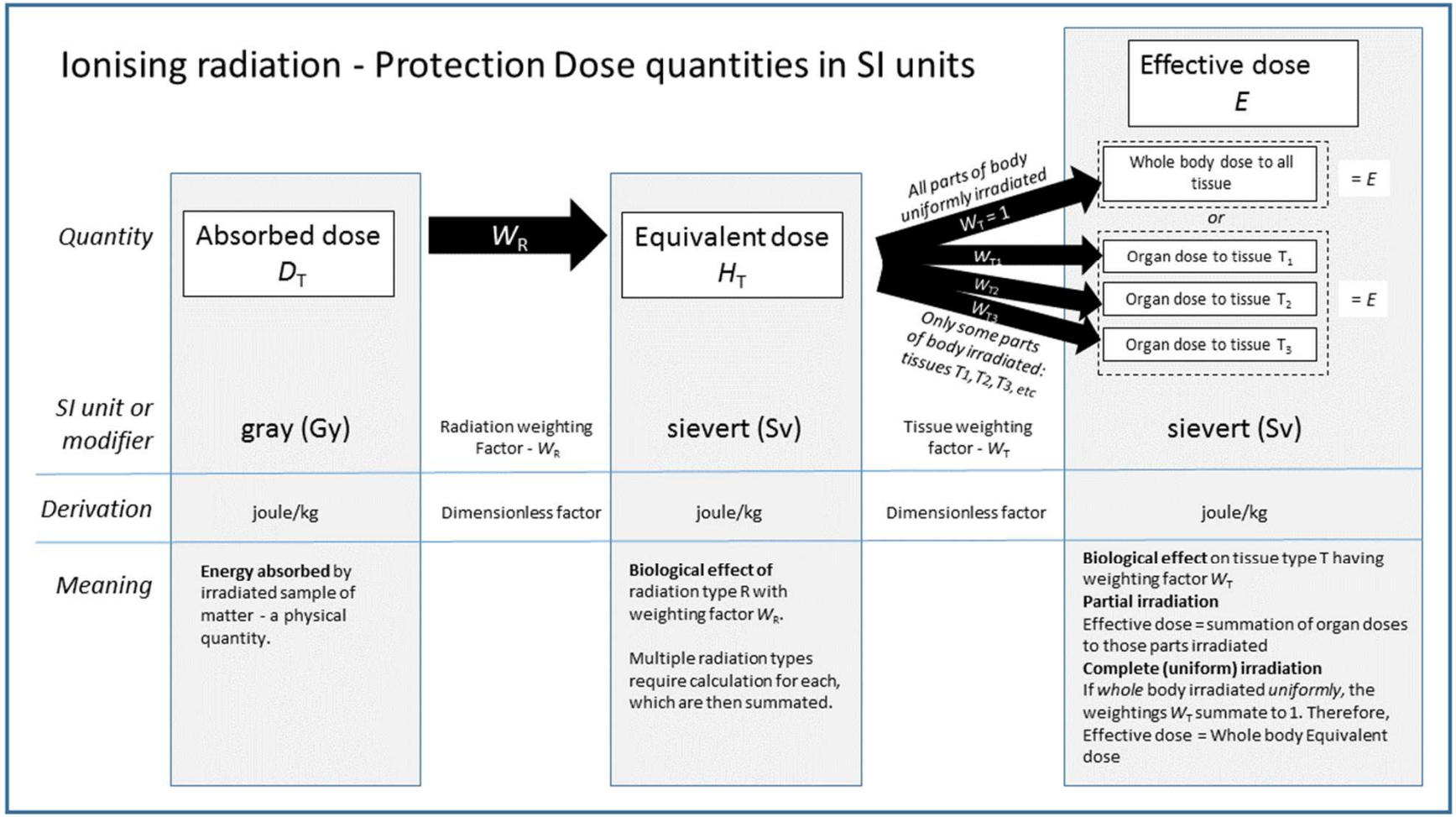

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Dose Rate Measurements

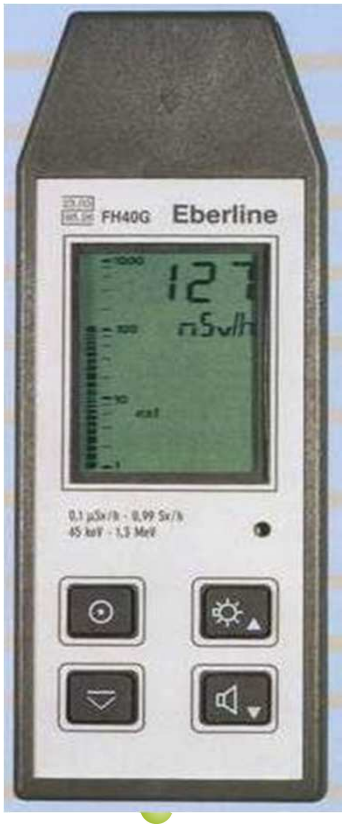
Be Carefull with the Units !!!

- mSv/h

- µSv/h

- nSv/h

Some Examples & Demos



Questions ?

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