

“Town and Gown Seminar”
Department of Physics
Covenant University, Ota.

ELECTROMAGNETIC SPECTRUM: INNOVATIVE AND EFFECTIVE TOOL FOR TECHNOLOGY DEVELOPMENT

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OUTLINES

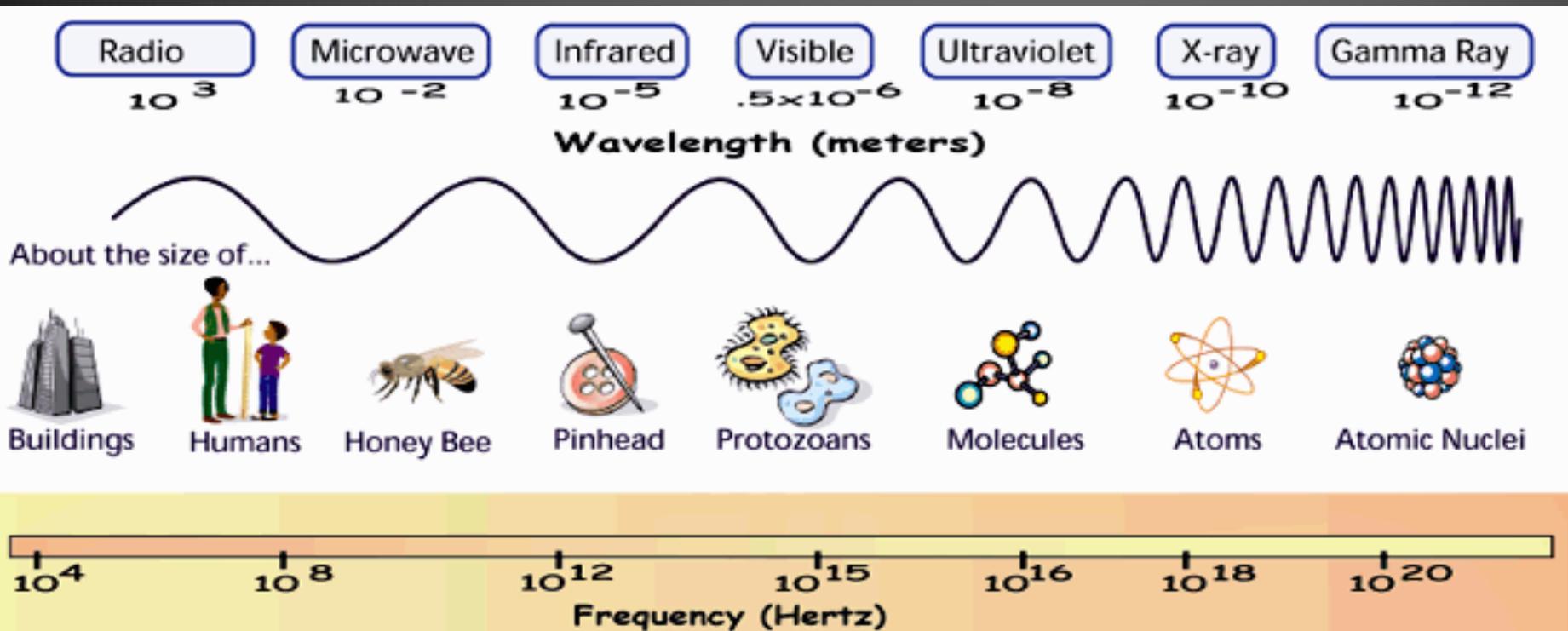
- ▶ Introduction
- ▶ The Electromagnetic Spectrum(EM)
- ▶ Application of EM Spectrum in technology development
- ▶ The harmful part of EM Spectrum
- ▶ Some Ionizing radiation detectors
- ▶ Conclusion

Introduction

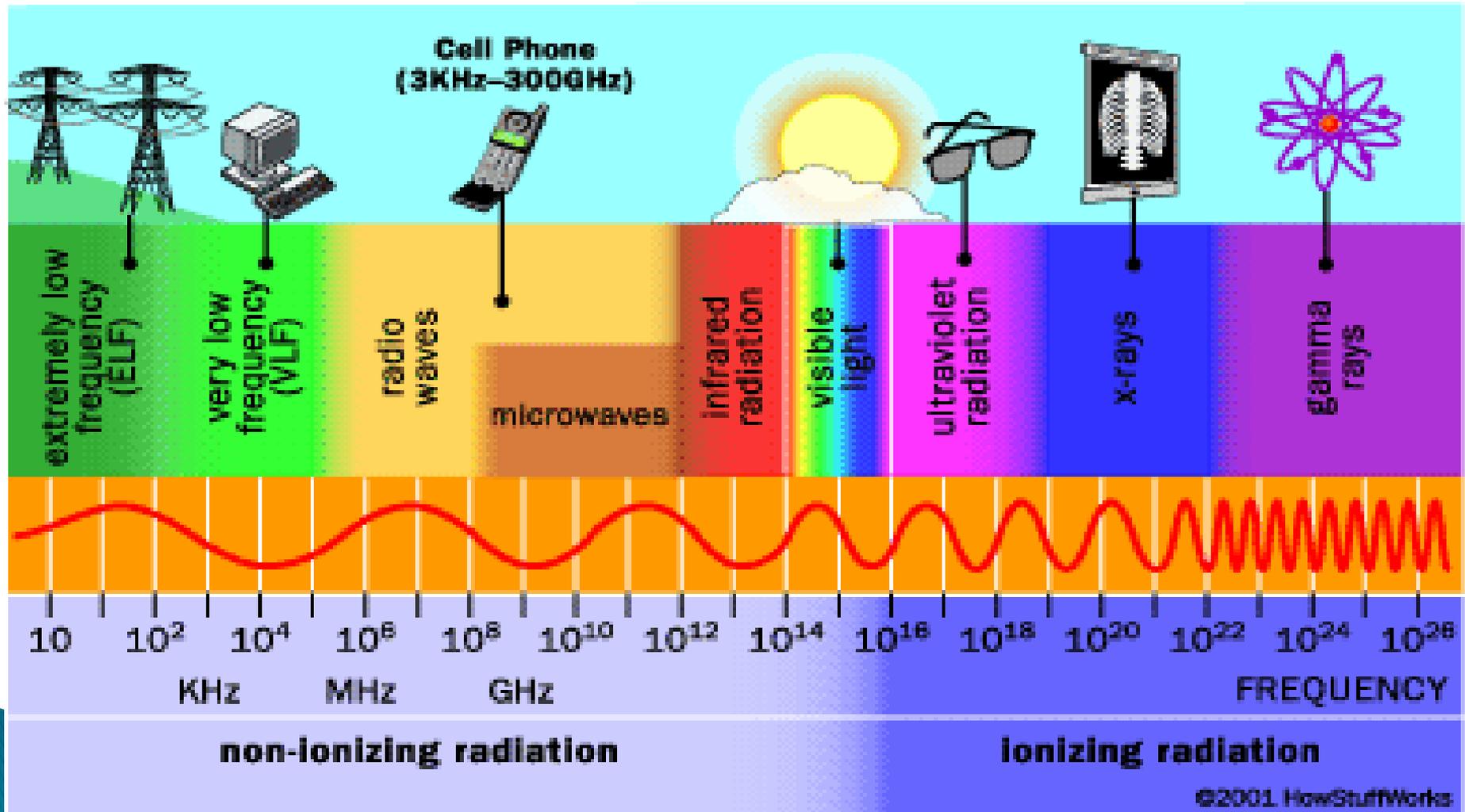
- ▶ Electromagnetic spectrum (radiation technology) is one of the powerful tool in developed and developing countries for the success of strong economies.
- ▶ It can make major contribution to economic growth, and have an important role to play in support of sustainable development.
- ▶ Radiation technology can preserve the past by protecting our cultural heritage, help us in the present and lead us into beautiful future through its application.

The Electromagnetic spectrum

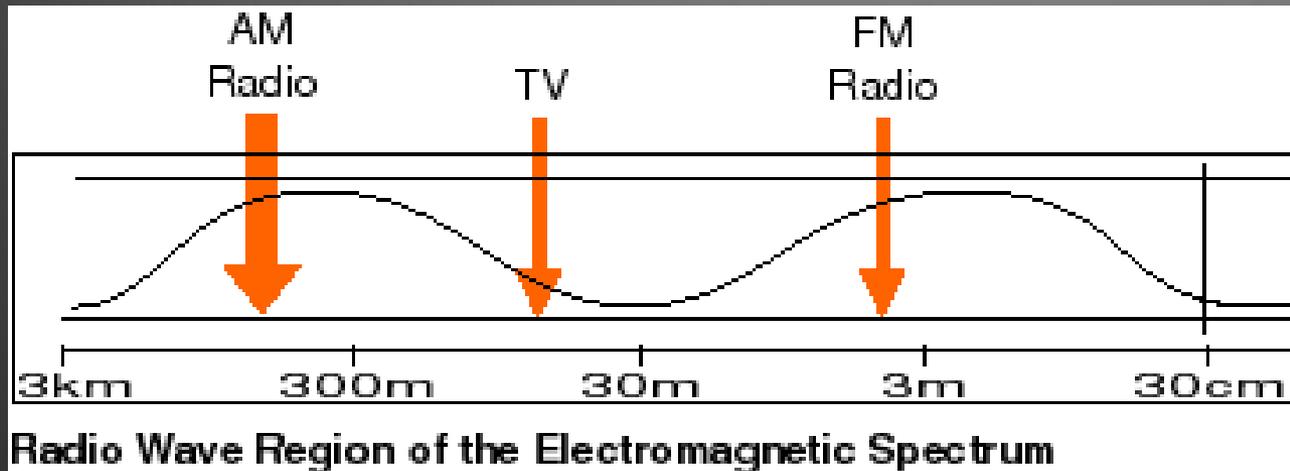
Electromagnetic spectrum is the entire distribution of electromagnetic radiation according to frequency or wavelength. Although all electromagnetic waves travel at the speed of light in a vacuum, they do so at a wide range of frequencies, wavelengths, and photon energies.



APPLICATION OF EM SPECTRUM IN TECHNOLOGY DEVELOPMENT



Radio waves



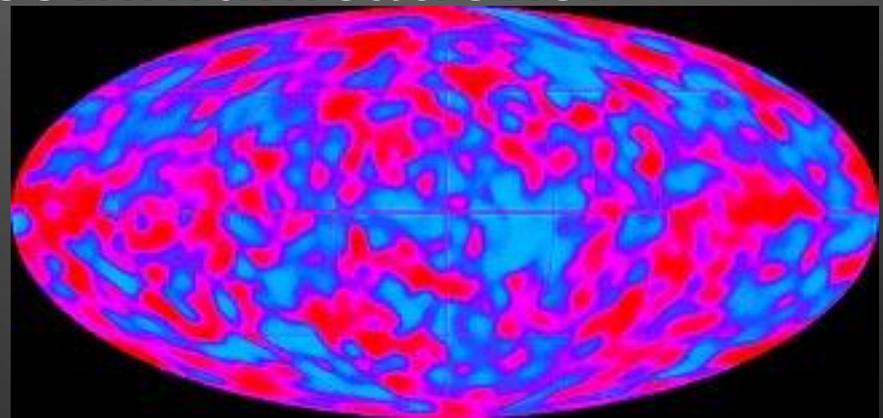
Radio waves are used for broadcasting sound and television. They are very useful as they bounce off the ionosphere and can therefore travel long distances.

Radio waves can be transmitted and received by reliable antennas.

Microwaves

Microwaves are useful for cooking food but are also used for communications.

Microwaves can pass through clouds without being affected. They are used for mobile phones and satellite communications.



The Amazon and the background radiation of space.

Microwave heating

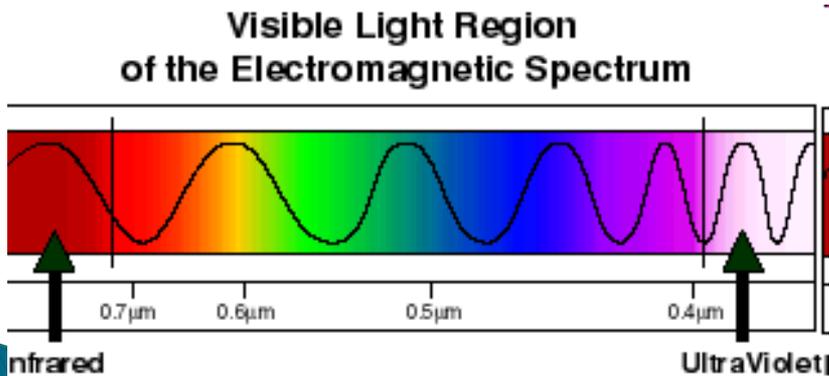
- The microwaves used in a cooking machine are about 12 cm long. They **vibrate water** and fat particles to make them **hot**. Microwaves cannot go very far into food which is why big turkeys cannot be cooked in a normal microwave oven.
- Microwaves given off by a cooker or a mobile phone can cause the **heating of internal body parts**. A cooker has a **shield** on it to stop this happening. Mobile phones only cause a tiny amount of heating and are not really very dangerous. Just don't phone for a long time .

Infra Red

- All objects that have a temperature give off some Infra Red (IR) radiation.
- A heater or grill or toaster uses IR radiation to heat a room or cook some food.
- Too much IR radiation, such as sticking your hand under a grill, can cause burns to our skin.

Visible light

- Only type of EM wave able to be detected by the human eye
- Violet is the highest frequency light
- Red light is the lowest frequency light



Wavelengths of Light – Visible

- ▶ What we see as white light is actually made up of a continuum of components
- ▶ Traditionally, we break white light into red, orange, yellow, green, blue, indigo, and violet (ROY G BIV)
- ▶ There is actually a continuous transition of color, each with its own wavelength and frequency

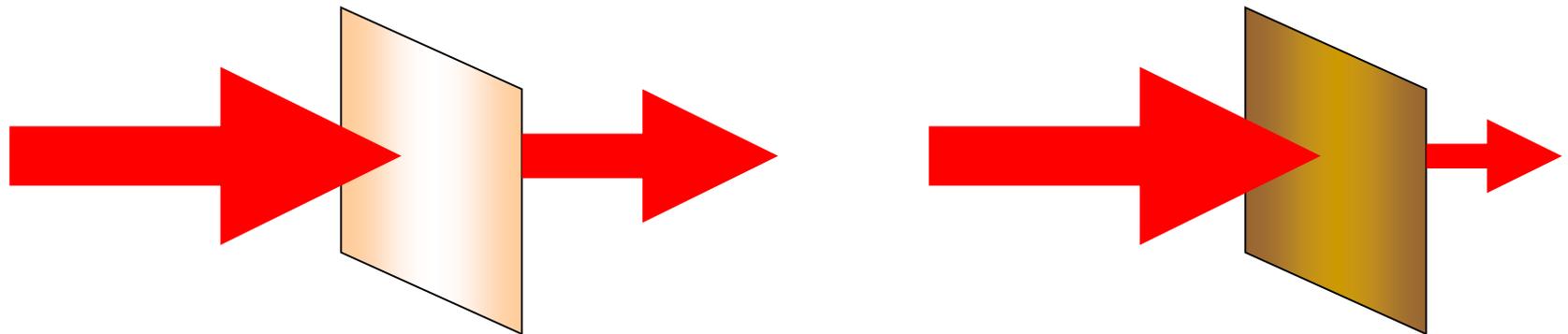


Ultra Violet

- ▶ UV is the longest wavelength radiation whose photons are energetic enough to ionize atoms, separating electrons from them, and thus causing chemical reactions.
- ▶ Short wavelength UV and the shorter wavelength radiation above it (X-rays and gamma rays) are called ionizing radiation, and exposure to them can damage living tissue, making them a health hazard.
- ▶ UV can also cause many substances to glow with visible light; this is called fluorescence.

Ultraviolet radiation can pass through skin to deeper tissues.

What effect do you think the colour of the skin has on the amount of radiation that passes through it?



The darker the skin, the more ultraviolet radiation is absorbed, and the less can reach into deeper soft tissues.

X-rays

- X-rays are very small waves that can pass through our bodies. Some X-rays can pass through flesh but not bone, this lets us see shadows of our bones.
- X-rays are very dangerous and can cause cancer. In small doses they are less likely to cause cancer and are very useful for looking for broken bones.
- X-rays are also very useful for looking inside all sorts of objects. They are used to find cracks in pipes and aircraft parts. They are also useful for looking inside suitcases without having to open them.



Analytical X-rays

- ▶ Two X-ray analytical methods are commonly used as research tools .

Diffraction [XRD]

X-ray scattering from crystalline materials yields a “fingerprint” of crystalline structure. Data from the scattered beam is checked against a library of known spectra to identify the material.

Fluorescence [XRF]

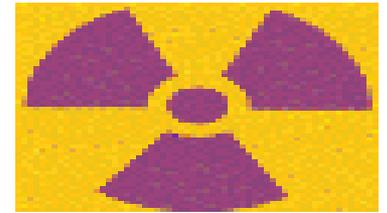
Emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays.



Diagnostic X-rays

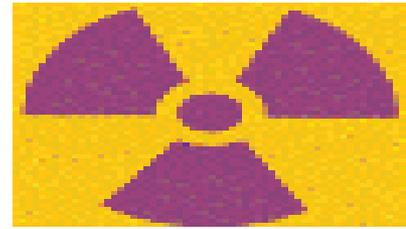
- **Two main types of diagnostic X-ray devices:**
- **Radiograph** – a picture with film or image is sent direct to computer screen. These are quick ‘shots’.
- **Fluoroscopic** – a real time “moving” inspection on inside functions. These longer exposures yield high doses.

Diagnostic X-rays



- ▶ **Diagnostic radiology** is the branch of medicine that involves taking and reading X-rays.
- ▶ The physicians that prescribe the shots and the technologists that operate the machines are specifically trained and licensed to perform these tasks.
- ▶ They also stay current through continuing education. Institutions are always striving to get quality images with the minimum patient exposure.

Industrial X-rays

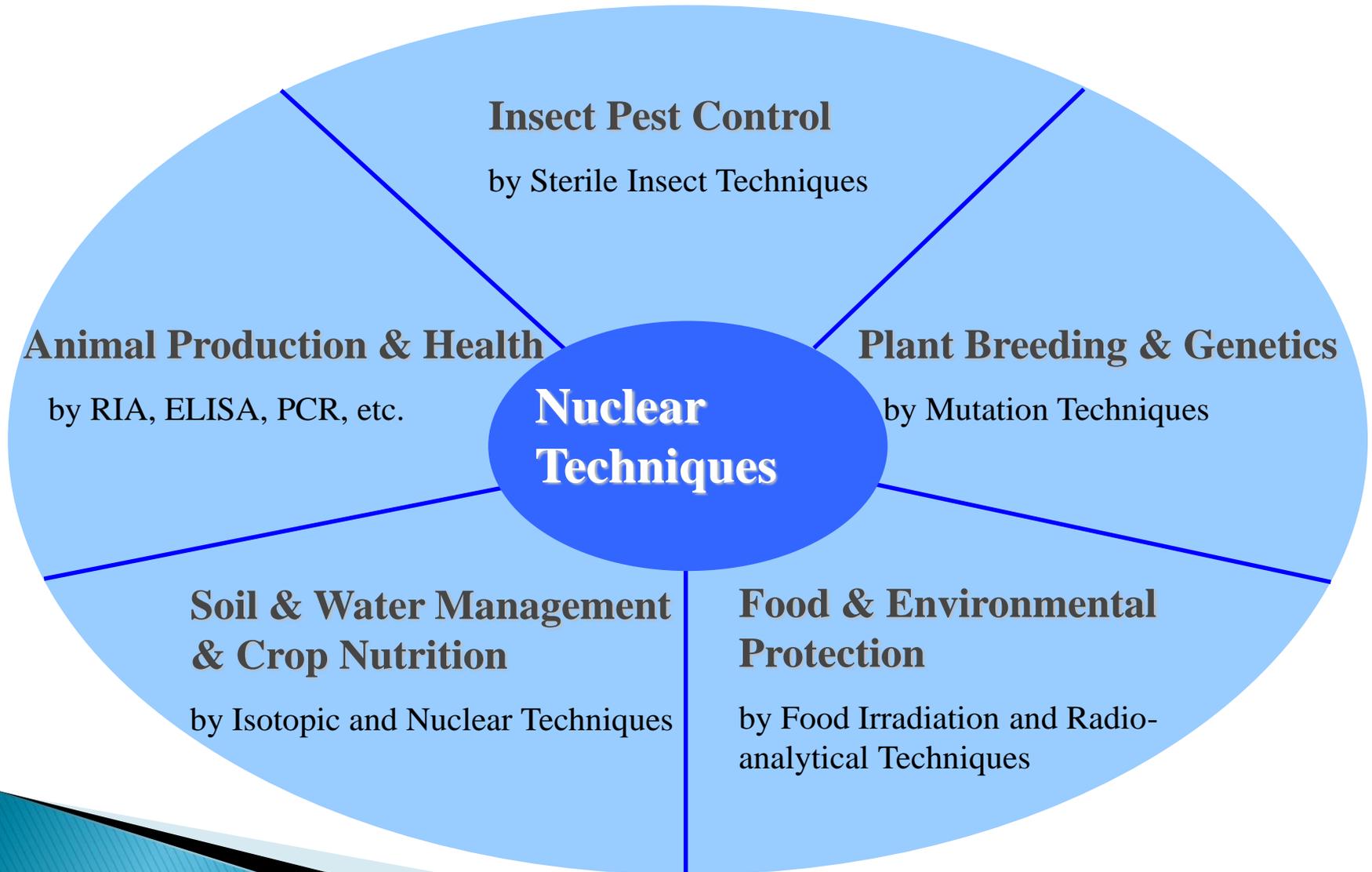


- ▶ X-rays are used for **non-destructive testing (NDT)** and have applications in a wide range of industries. Engineering classes sometimes use these methods.
- ▶ NDT uses X-ray beams (or gamma or beta emissions from a radiation source) to inspect products or processes without damaging them. This discipline is called **Industrial radiography**.
- ▶ Industrial X-ray machines are used primarily to find defects in castings, structures, and welds, find foreign material in food products, and to inspect luggage at airports, building entries etc.

Gamma-rays

- ▶ Gamma-rays are the most energetic photons, having no defined lower limit to their wavelength.
- ▶ In astronomy they are valuable for studying high-energy objects or regions, however as with X-rays this can only be done with telescopes outside the Earth's atmosphere.
- ▶ Gamma rays are used experimentally by physicists for their penetrating ability and are produced by a number of radioisotopes.

Application of gamma-rays in Food and Agriculture



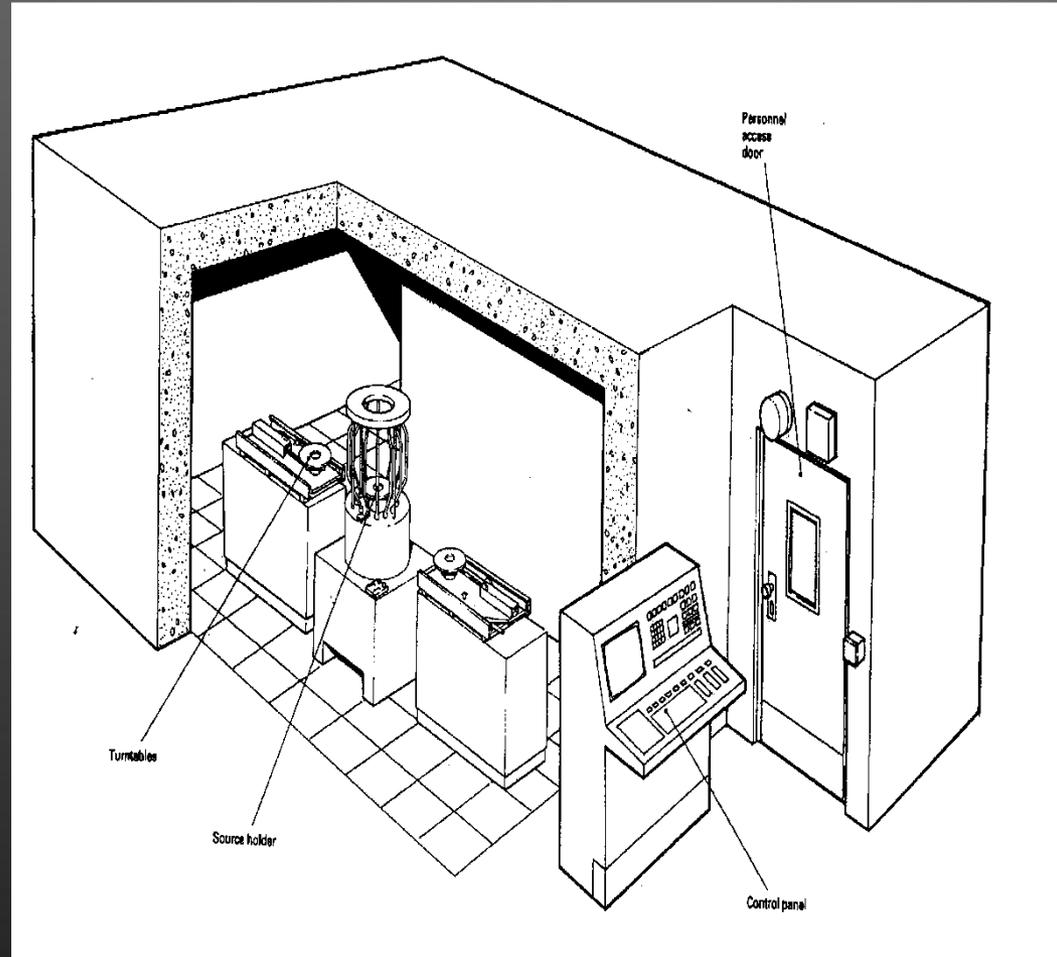
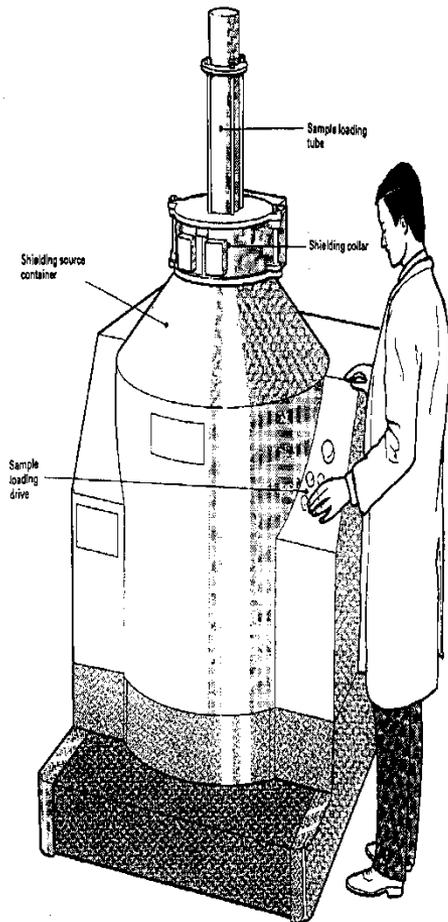
Using Gamma rays



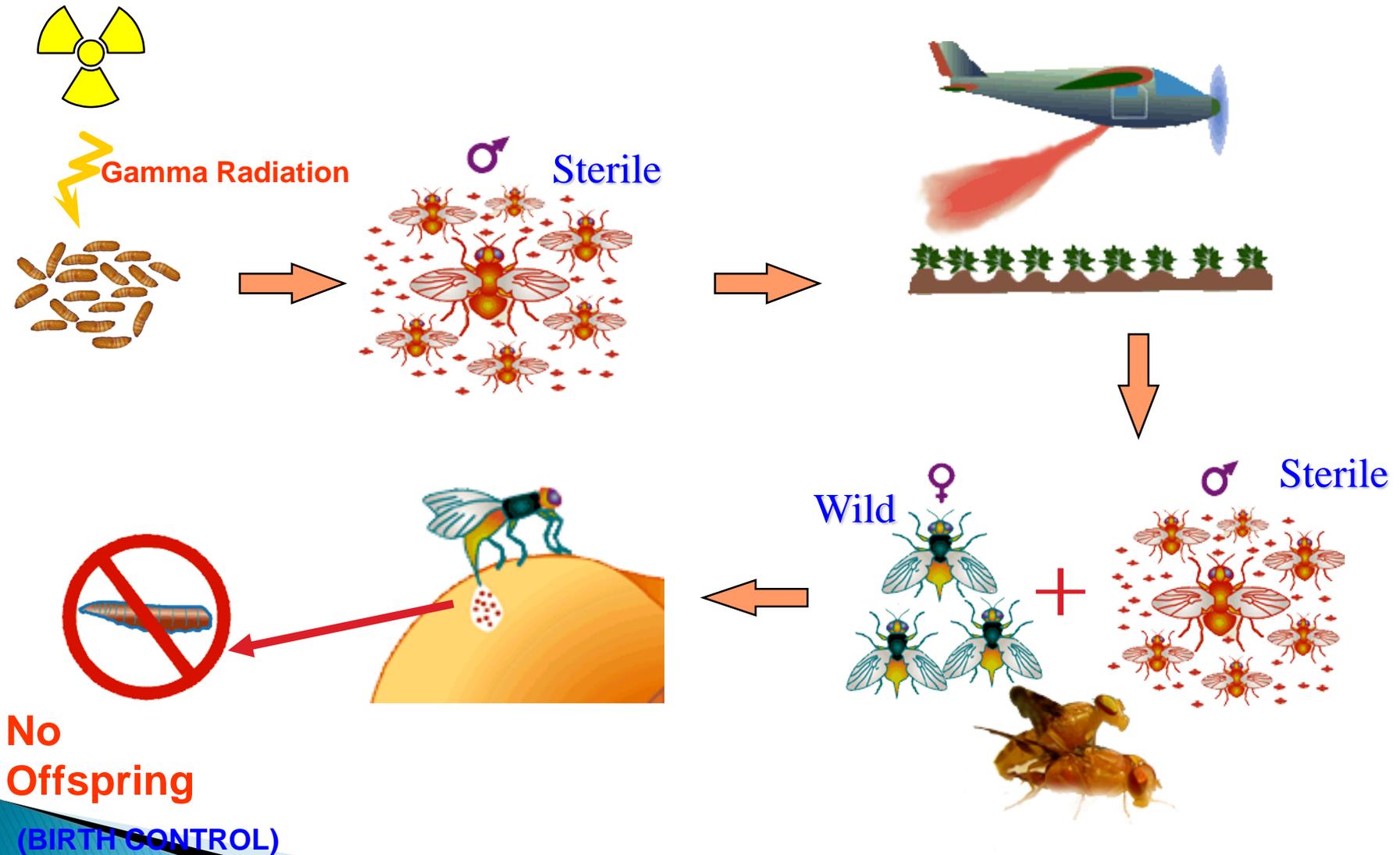
Gamma rays can be used to kill bacteria living on **fruits**, such as strawberries, so that they last longer before becoming rotten.

The gamma irradiation does not affect the quality of the fruit. Many **meats**, such as chicken and pork, are also irradiated. Gamma radiation saves thousands of lives each year.

Gamma Irradiator



Insect Pest Control by SIT



Insect Control

- ▶ Crop losses caused by insects may amount to more than 10% of the total harvest worldwide, – in developing countries the estimate is 25–35%.
- ▶ Chemical insecticides have for many years been the main weapon in trying to reduce these losses, but they have not always been effective. Some insects have become resistant to the chemicals used, and some insecticides leave poisonous residues on the crops.

- ▶ One solution has been the use of sterile insects.
 - ▶ The Sterile Insect Technique (SIT) involves rearing large numbers of insects then irradiating their eggs with gamma radiation before hatching, to sterilise them.
 - ▶ The sterile males are then released in large numbers in the infested areas. When they mate with females, no offspring are produced. With repeated releases of sterilised males, the population of the insect pest in the project area is drastically reduced.
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Water Resources using Isotopes technique.

- ▶ Isotope hydrology techniques enable accurate tracing and measurement of the extent of underground water resources. Such techniques provide important analytical tools in the management and conservation of existing supplies of water and in the identification of new, renewable sources of water.
 - ▶ They provide answers to questions about origin, age and distribution of groundwater, as well as the interconnections between ground and surface water and aquifer recharge systems.
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- ▶ The results permit planning and sustainable management of these water resources.
 - ▶ For surface waters they can give information about leakages through dams and irrigation channels, the dynamics of lakes and reservoirs, flow rates, river discharges and sedimentation rates.
 - ▶ From Afghanistan to Zaire there are some 60 countries, developed and developing, that have used isotope techniques to investigate their water resources in collaboration with IAEA.
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Sterilisation



Gamma rays can be used to **sterilise** all sorts of **medical equipment** to make sure that patients do not become infected by bacteria. Even a tiny amount of bacteria can grow to become a life threatening illness for a post operative patient.

Therapy

- The uses of radioisotopes in therapy are comparatively few, but important. Cancerous growths are sensitive to damage by radiation, which may be external – using a gamma beam from a cobalt-60 source, or internal – using a small gamma or beta radiation source.
- Short-range radiotherapy is known as brachytherapy, and this is becoming the main means of treatment. Many therapeutic procedures are palliative, usually to relieve pain

Iodine-131 is commonly used to treat thyroid cancer, probably the most successful kind of cancer treatment, and also for non-malignant thyroid disorders.

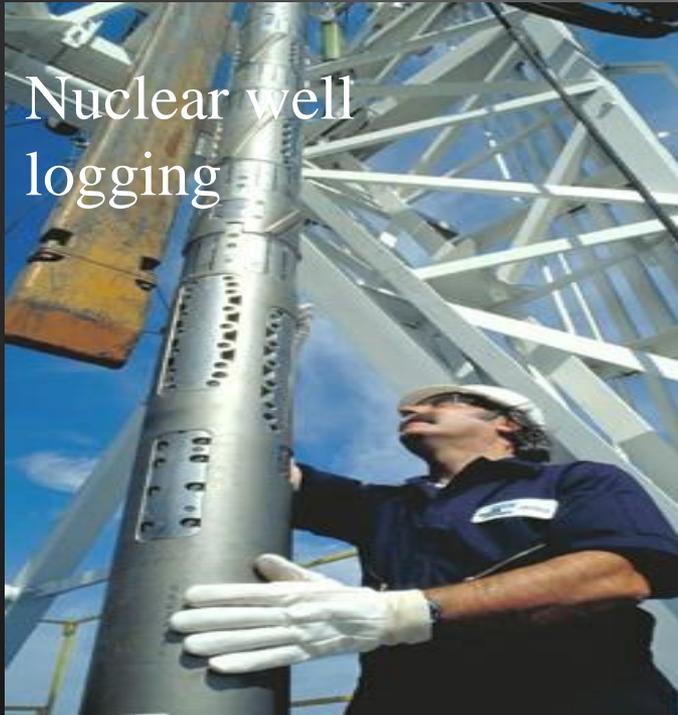
Iridium-192 wire implants are used especially in the head and breast to give precise doses of beta rays to limited areas, then removed.

A new treatment uses samarium-153 complexed with organic phosphate to relieve the pain of secondary cancers lodged in bone.

Gamma camera



Application of gamma rays in well logging and road construction



Nuclear well logging



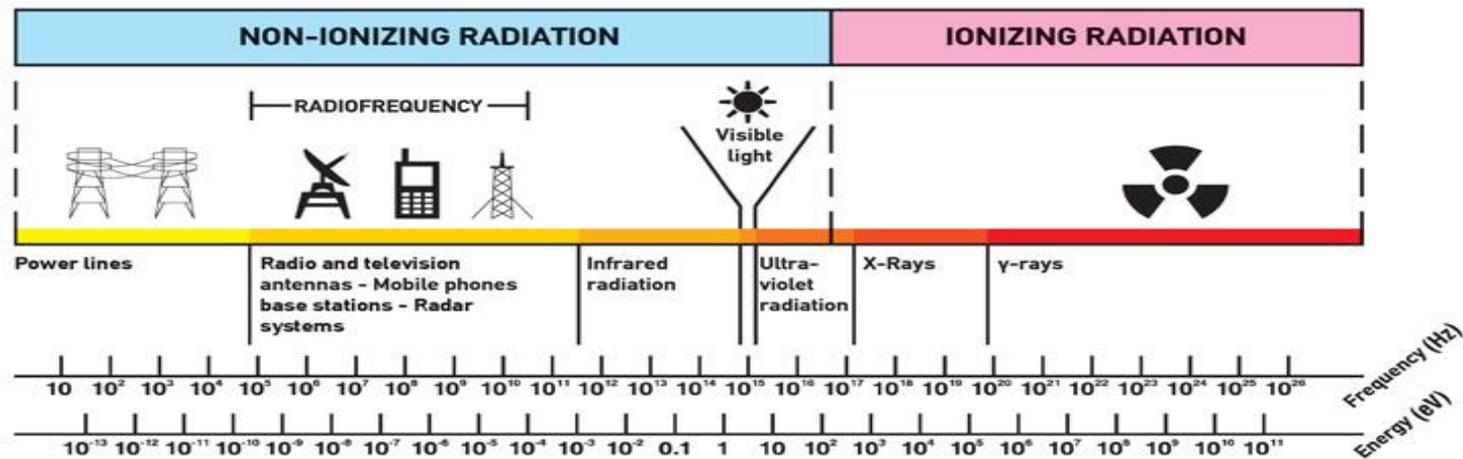
Density gauge

Gamma-gamma or density log contains ^{137}Cs of $< 75 \text{ GBq}$ gamma backscattered to two detectors

density log with porosity log indicates presence of gas

The harmful part of EM Spectrum

Ionizing radiation is useful for many purposes: radiotherapy, diagnosis, industrial processes, nuclear power..... However, from the first pioneers it was well known that humans not only could obtain benefit from ionizing radiation, there were also associated health hazards.



The harmful part of EM Spectrum

Ionizing radiations have many beneficial applications, but they also may have detrimental consequences for human health and for environment.

There is need to protect ourselves from the harmful effect of Ionizing radiation.

Ionizing radiation is invisible, without the use of monitoring equipment, humans are not able to feel , taste, smell, or hear ionizing radiation.

Damaging UV

- Unfortunately UV light is damaging to our eyes and skin. Frequent exposure can lead to eye problems and even blindness (Galileo).
- UV light can also cause skin cancer, which is why you should wear sun block even if your skin does not burn.
- The Earth is protected from a lot of UV light by the ozone layer; unfortunately chemicals from industries have made a big hole in the layer.



X-Ray Effects

- ▶ The effects of x-ray exposure depends upon:
- ▶ Duration/Exposure time – How fast the dose is delivered.
- ▶ Energy – How much energy was in the x-ray
 - Low Energy (<50 KeV) – damage only to skin or outer part of body
 - High Energy – damage to internal organs
- ▶ Total Dose – The magnitude of the dose

Gamma -ray effect

Health effects of gamma radiation depend on the circumstances and the dose-rate of radiation being received.

- . Radiation can be classified into acute radiation and chronic exposure radiation.**

Damage or potential damage depends on:

radiation type
dose and dose rate
cell type

Erythema on arm (x-ray burn)



Blistering/tissue damage



Localised burn



Tissue damage to fingers



Severe burns

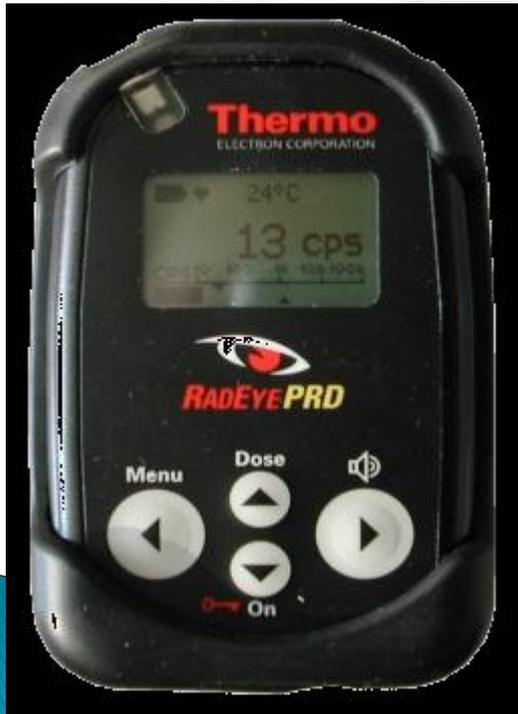


Localised burns

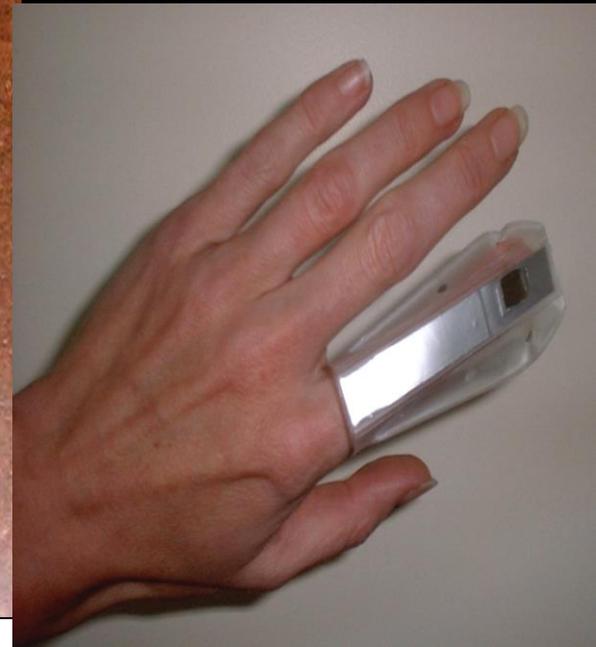
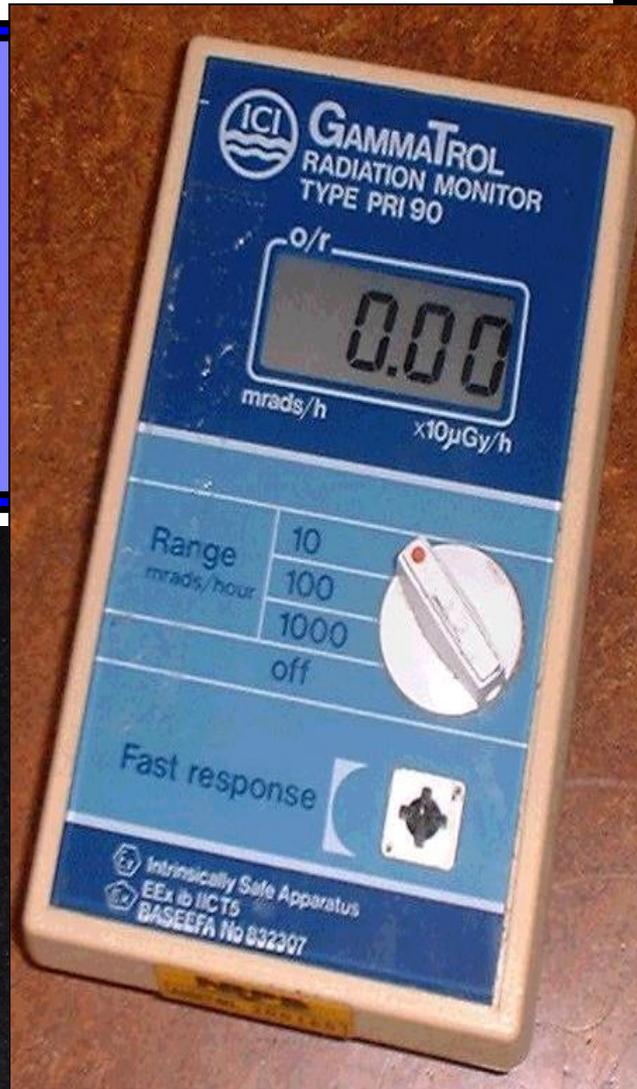
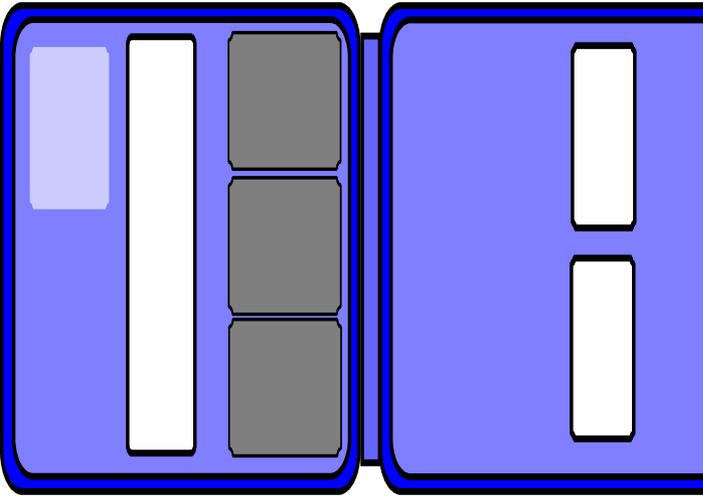




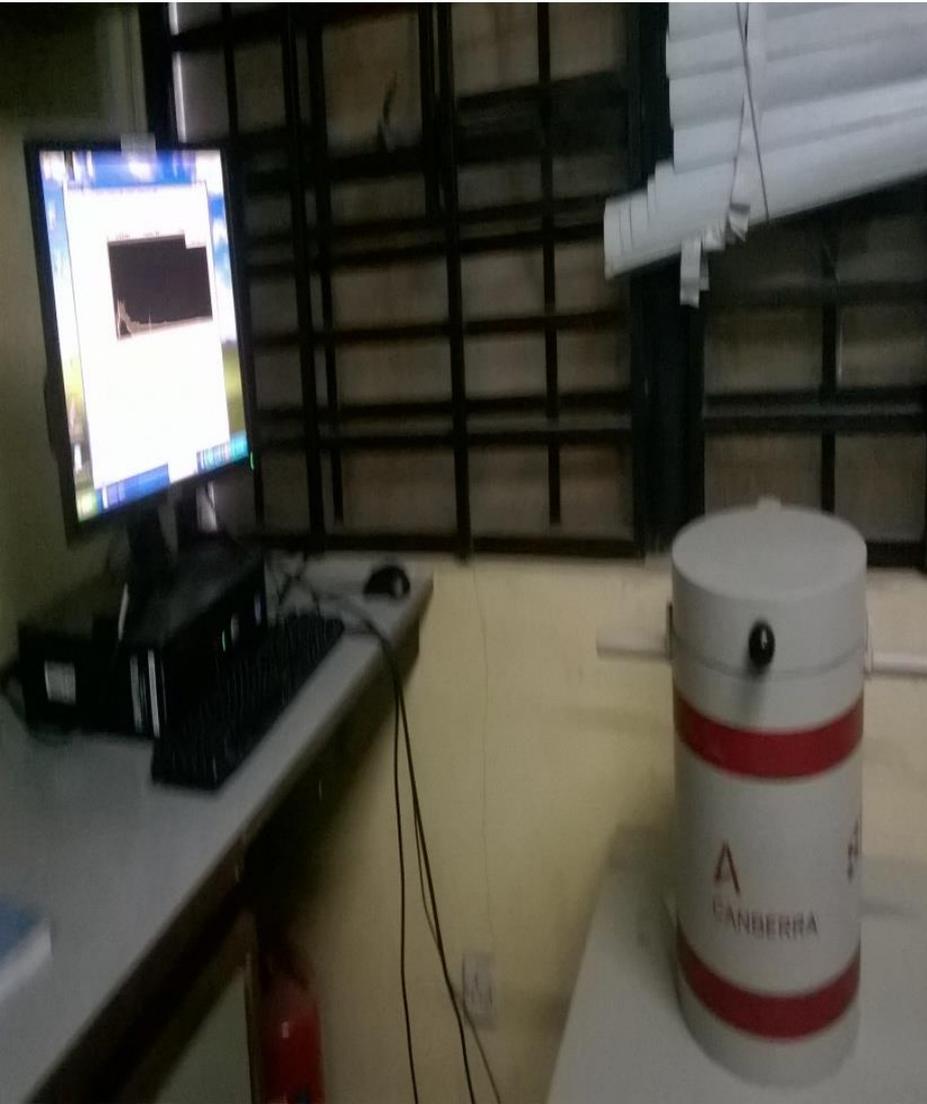
Some detectors for detecting ionizing radiation (in-situ)



Some detectors for detecting ionizing radiation (in-situ)

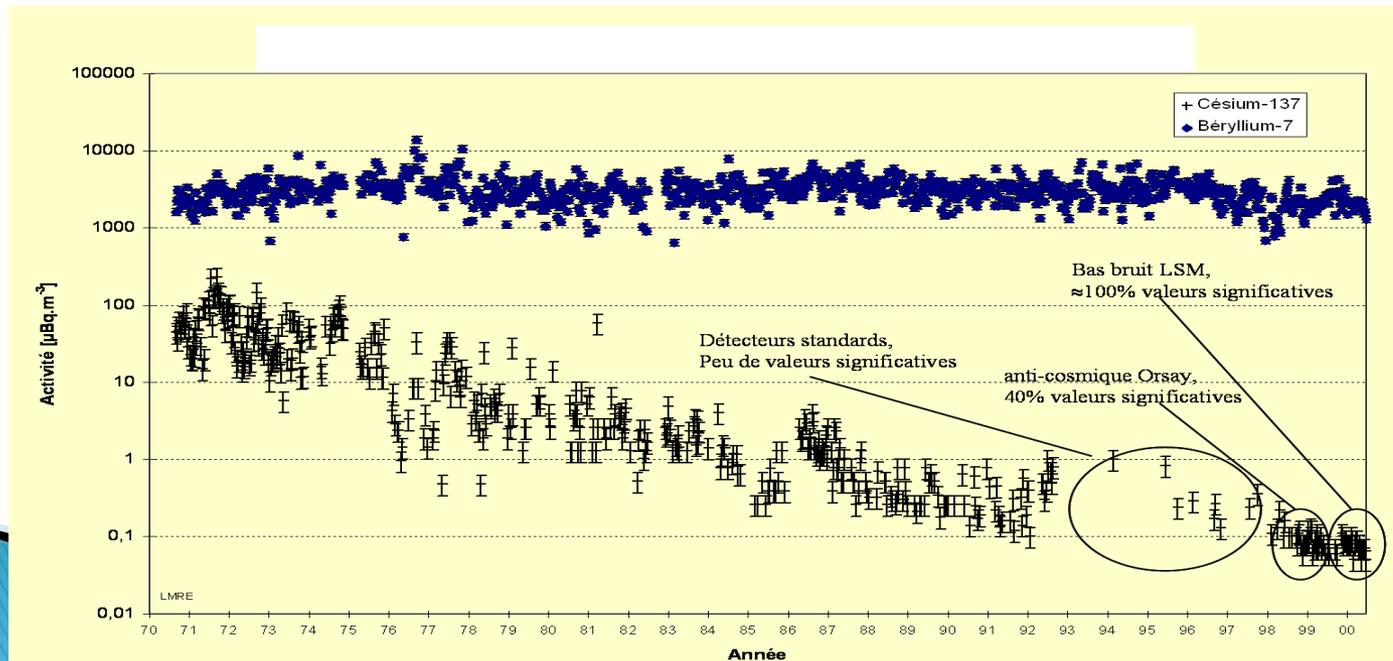


Some detectors for detecting ionizing radiation (Laboratory)



Environmental monitoring

- ▶ **Monitoring of radioactive contamination in the atmosphere**
- ▶ Measurements of artificial radionuclides in certain samples require very low backgrounds.



CONCLUSION

- ▶ Electromagnetic spectrum (Radiation technology) is an effective tool that has the potential to boost industrial development, improving productivity in a cost-effective and environmentally-sound way.
- ▶ EM is like a ray of hope which can preserve the past by protecting our cultural heritage, help us in the present by creating materials to support agriculture, and lead us into the future through its application in the field of nanoscale engineering.

Conclusion cont'

- ▶ The ionizing part of EM spectrum is a tool that is useful but harmful.
- ▶ This part of EM spectrum can be detected by a good and well calibrated detector, protected by observing the radiation protection principle and monitored by a very good spectrometer.
- ▶ “A knife is useful but can also cut”.

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Thank you for your attention

