

# What is Ionizing Radiation?

January 2003

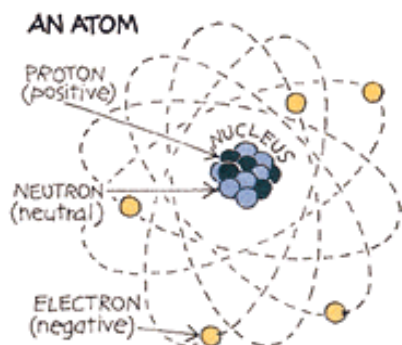
## Fact Sheet #3

Division of Environmental Health  
Office of Radiation Protection



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## IONIZING RADIATION



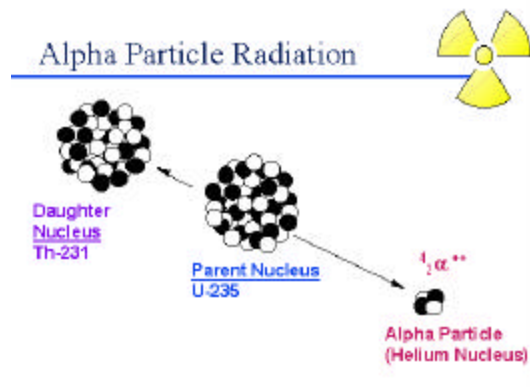
Ionizing radiation is radiation that has sufficient energy to remove orbital electrons from atoms, leading to the formation of ions. In this document, ionizing radiation will be referred to simply as radiation. One source of radiation is the nuclei of unstable atoms. For these radioactive atoms (also referred to as radionuclides or radioisotopes) to become more stable, the nuclei eject or emit subatomic particles and high-energy photons (gamma rays). This process is called radioactive decay. Unstable isotopes of radium, radon, uranium, and thorium, for example, exist naturally. Others are

continually being made naturally or by human activities, such as the splitting of atoms in a nuclear reactor. Either way, they release ionizing radiation.

## Types of Ionizing Radiation

- ◆ Alpha Particle Radiation
- ◆ Beta Particle Radiation
- ◆ Gamma Ray Radiation
- ◆ X-Ray Radiation

## Alpha Particle Radiation



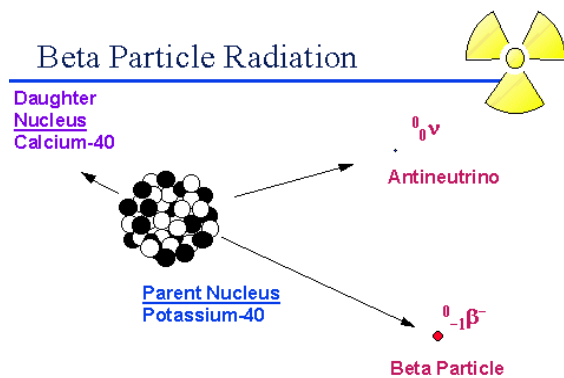
An **alpha particle** consists of two neutrons and two protons ejected from the nucleus of an atom. The alpha particle is identical to the nucleus of a helium atom. Examples of alpha emitters are radium, radon, thorium, and uranium.

Because alpha particles are charged and relatively heavy, they interact intensely with atoms in materials they encounter, giving up their energy over a very short range. In air, their travel distances are limited to approximately an inch.

Alpha particles are easily shielded against and can be stopped by a single sheet of paper. Since alpha particles cannot penetrate the dead layer of the skin, they do not present a hazard from exposure external to the body.

However, due to the very large number of ionizations they produce in a very short distance, alpha emitters can present a serious hazard when they are in close proximity to cells and tissues such as the lung. Special precautions are taken to ensure that alpha emitters are not inhaled, ingested or injected.

## Beta Particle Radiation

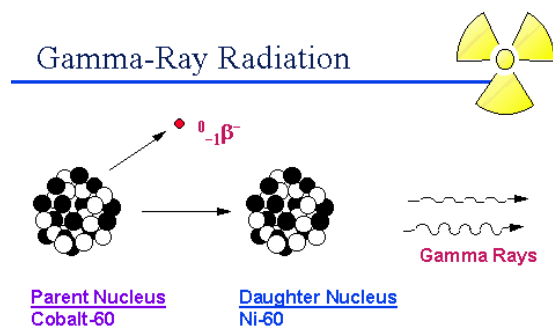


A **beta particle** is an electron emitted from the nucleus of a radioactive atom. Examples of beta emitters commonly used in biological research are: hydrogen-3 (tritium), carbon-14, phosphorus-32, phosphorus-33, and sulfur-35.

Beta particles are much less massive and less charged than alpha particles and interact less intensely with atoms in the materials they pass through, which gives them a longer range than alpha particles. Some energetic beta particles, such as those from P-32, will travel up to several feet in air or approximately one half of an inch into the skin, while low energy beta particles, such as those from H-3, are not capable of penetrating the dead layer of the skin. Thin layers of metal or plastic stop beta particles

All beta emitters, depending on the amount present, can pose a hazard if inhaled, ingested or absorbed into the body. In addition, energetic beta emitters are capable of presenting an external radiation hazard, especially to the skin.

## Gamma Ray Radiation



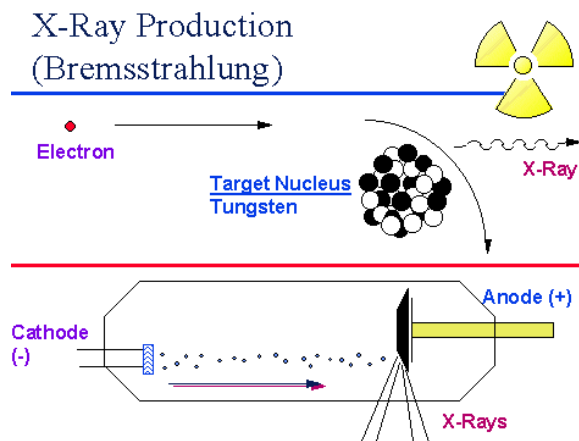
A **gamma ray** is a packet (or photon) of electromagnetic radiation emitted from the nucleus during radioactive decay and occasionally accompanying the emission of an alpha or beta particle. Gamma rays are identical in nature to other electromagnetic radiations such as light or microwaves but are of much higher energy. Examples of gamma emitters are cobalt-60, zinc-65, cesium-137, and radium-226.

Like all forms of electromagnetic radiation, gamma rays have no mass or charge and interact less intensively with matter than ionizing particles. Because gamma radiation loses energy slowly, gamma rays are able to travel significant distances. Depending upon their initial energy, gamma rays can travel tens or hundreds of feet in air.

Gamma radiation is typically shielded using very dense materials (the denser the material, the more chance that a gamma ray will interact with atoms in the material) such as lead or other dense metals.

Gamma radiation particularly can present a hazard from exposures external to the body.

## X-Ray Radiation



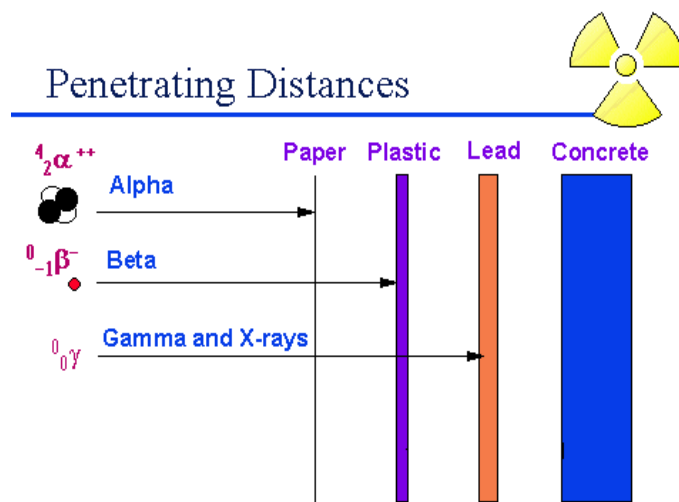
Like a gamma ray, an **x-ray** is a packet (or photon) of electromagnetic radiation emitted from an atom, except that the x-ray is not emitted from the nucleus. X-rays are produced as the result of changes in the positions of the electrons orbiting the nucleus, as the electrons shift to different energy levels. Examples of x-ray emitting radioisotopes are iodine-125 and iodine-131.

X-rays can be produced during the process of radioactive decay or as bremsstrahlung radiation. Bremsstrahlung radiation are x-rays produced when high-energy electrons strike a target made of a heavy metal, such as tungsten or copper. As electrons collide with this material, some have their paths deflected by the nucleus of the metal atoms. This deflection results in the production of x-rays as the electrons lose energy. This is the process by which an x-ray machine produces x-rays.

Like gamma rays, x-rays are typically shielded using very dense materials such as lead or other dense metals.

X-rays particularly can present a hazard from exposures external to the body.

## PENETRATING DISTANCES AND SHIELDING



It is important to know how far a radiation can penetrate through various materials. This information is well understood and well documented, and used to create physical shielding, or a barrier, to the radiation source. If you increase the shielding around a radiation source, it will decrease your exposure. For example, if you stand out in the rain *without* an umbrella, you will get wet. But, if you use an umbrella to shield you from the rain, you will remain dry and protected. This is similar to the idea of shielding in radiation protection.

Alpha particles are usually completely absorbed by the outer dead layer of the human skin and, so, alpha emitting radioisotopes are not a hazard outside the body. However, they can be very harmful if they are ingested or inhaled. Alpha particles can be stopped completely by a sheet of paper.

Beta particles travel appreciable distances in air, but can be reduced or stopped by a layer of clothing, thin sheet of plastic or a thin sheet of aluminum foil.

Several feet of concrete or a thin sheet of a few inches of lead may be required to stop the more energetic gamma rays.

A thin layer of lead can stop medical x rays.

