Nuclear Physics and Radioactivity

Lectures 21

Ch 30

Mural painted on the birthplace of Marie Curie in Warsaw, in 2011. To mark the 100th anniversary of her second Nobel prize, which she shared with her daughter Irene.

Units of Chapter 30-31

- Radioactivity
- Alpha Decay
- Beta Decay
- Gamma Decay
- Structure and Properties of the Nucleus
- Binding Energy and Nuclear Forces
- Conservation of Nucleon Number and Other Conservation Laws
- Half-Life and Rate of Decay
- Radioactive Dating
- Detection of Radiation
- Nuclear Reactions and the Transmutation of Elements
- Nuclear Fission; Nuclear Reactors
- Nuclear Fusion

30.3 Radioactivity - and Ionizing Radiation

- Towards the end of the 19th century, minerals were found that would darken a photographic plate even in the absence of light.

- This phenomenon was named radioactivity by Marie Curie.

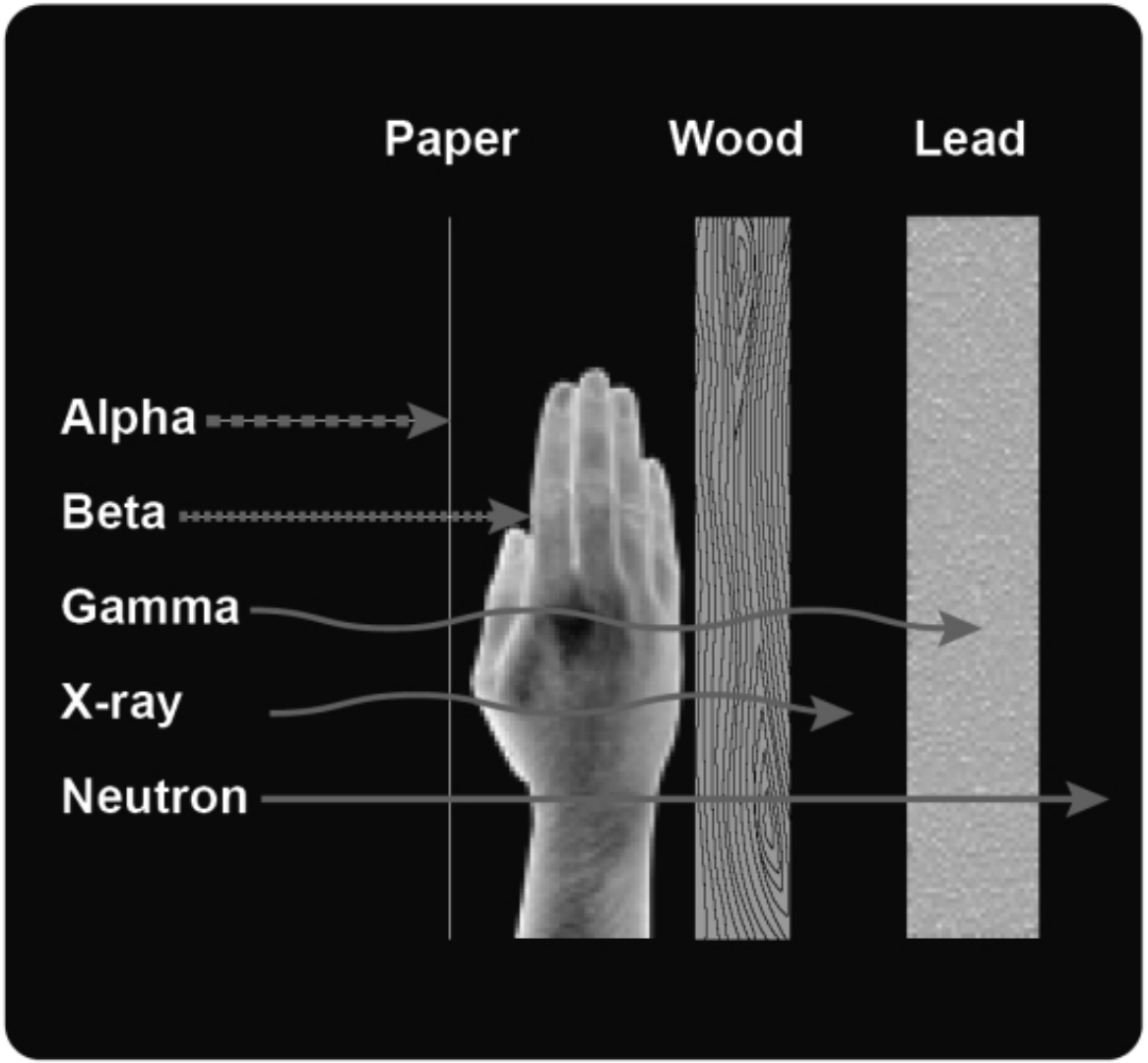
- Marie and Pierre Curie isolated two new elements from a uranium-bearing ore called Pitchblende: Radium and Polonium

- Most of the effects associated with "radiation" are due to ionization by high energy particles and photons.

- Find the Curie's full story, with photos, original notes, etc… at the American Institute of Physics website:

http://www.aip.org/history/curie/

Types of High energy Radiation



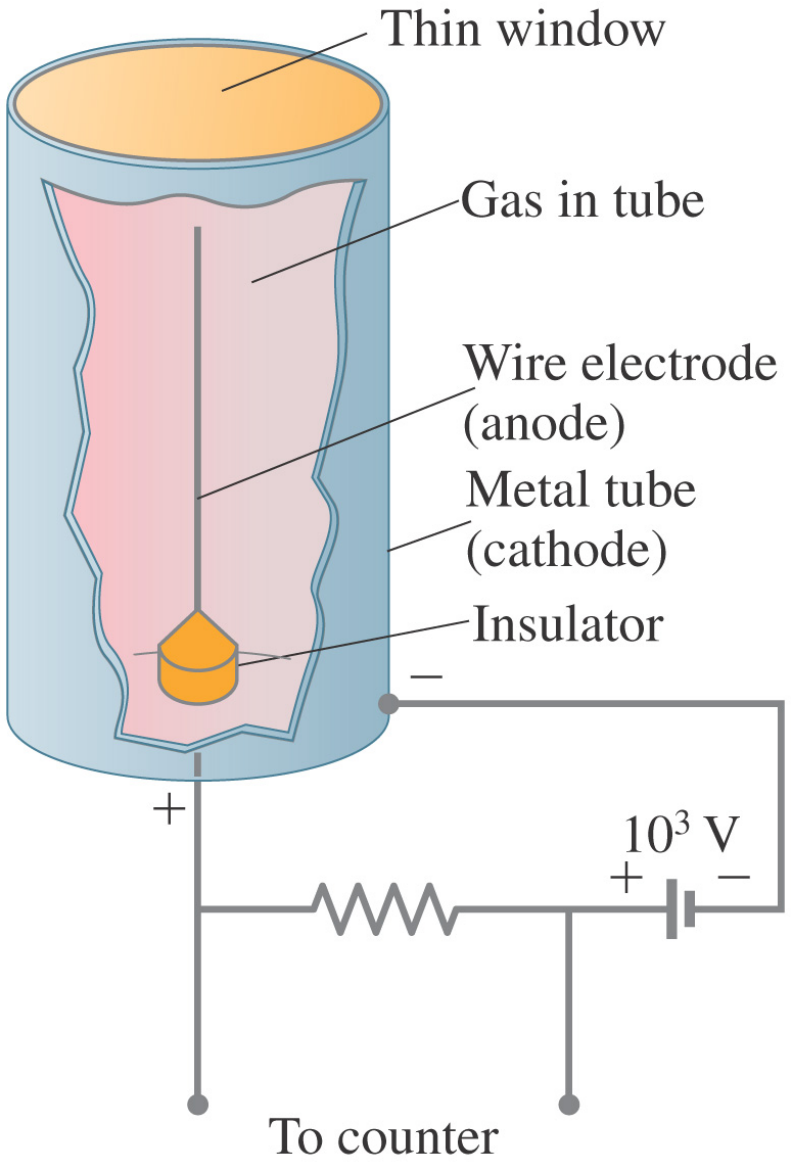
30.3 Radioactivity

Radioactive rays were observed to be of three types:

1. Alpha rays, which could barely penetrate a piece of paper
2. Beta rays, which could penetrate 3 mm of aluminum
3. Gamma rays, which could penetrate several centimeters of lead

We now know that alpha rays are helium nuclei, beta rays are electrons, and gamma rays are electromagnetic radiation.

30.13 Detection of Ionizing Radiation



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- The **Geiger counter** is a gas-filled tube with a wire in the center.
- The wire is at high voltage; the case is grounded.
- When a charged particle passes through, it ionizes the gas.
- The ions cascade onto the wire, producing a current pulse.

Using our Geiger counter to investigate samples of radioactive elements…..

What type of ionizing radiation is emitted by Polonium ?

A. Alpha
B. Beta
C. Gamma
D. Radio

Polonium is a chemical element with the symbol Po and atomic number 84, discovered in 1898 by Marie and Pierre Curie.

A rare and highly radioactive element with no stable isotopes, polonium is chemically similar to bismuth and tellurium, and it occurs in uranium ores.

Applications of polonium include heaters in space probes, and antistatic devices.

Infamous for its use in the 2006 radioactive poisoning case of Russian dissident Alexander Litvinenko in London.

Using our Geiger counter to investigate samples of radioactive elements…..

What type of ionizing radiation is emitted by Caesium?

A. Alpha
B. Beta
C. Gamma
D. Radio

A radioactive isotope of caesium is formed as one of the more common fission products by the nuclear fission of uranium-235 in nuclear reactors and nuclear weapons.

Caesium-137 is among the most problematic of the short-to-medium-lifetime fission products because it easily moves and spreads in nature due to the high water solubility of caesium's most common chemical compounds, which are salts.

Using our Geiger counter to investigate samples of radioactive elements…..

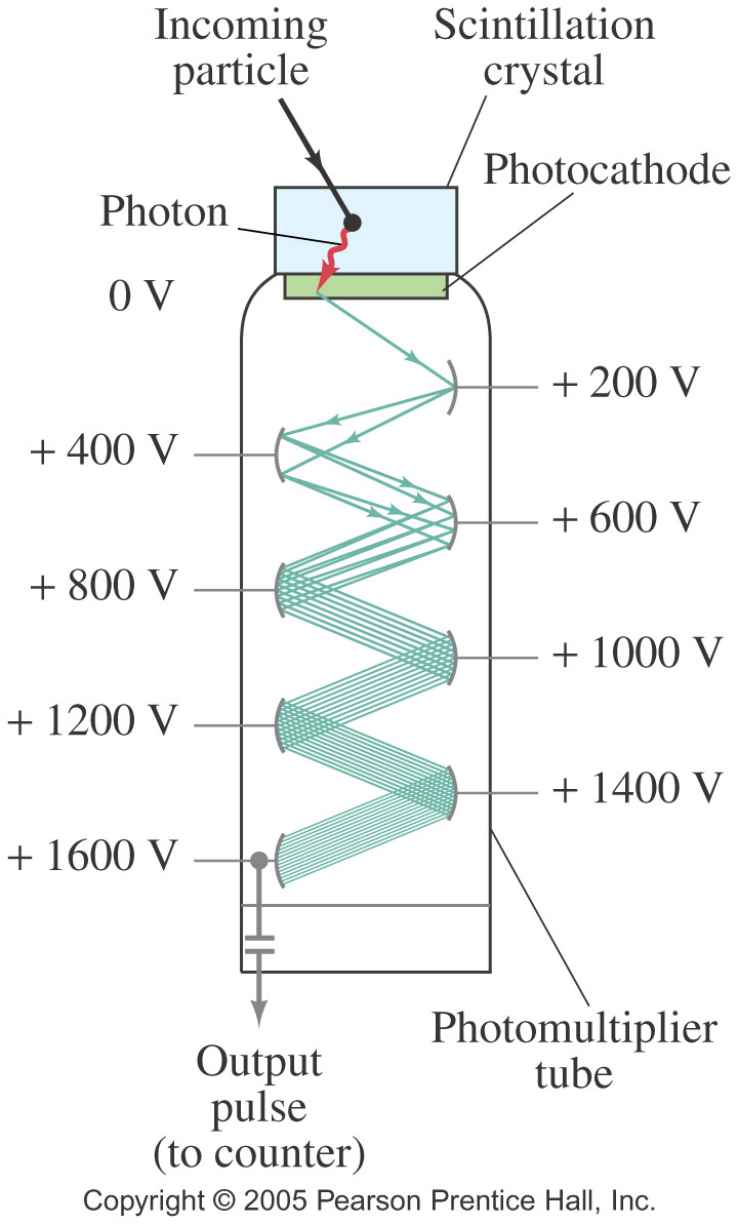
What type of ionizing radiation is emitted by Strontium?

A. Alpha
B. Beta
C. Gamma
D. Radio

Radioactive strontium is used in bone cancer therapy, as it mimics calcium, and is preferentially incorporated by regions of increased bone growth

Unstable isotopes Strontium are present in nuclear weapon fallout, and are a component of nuclear waste.

30.13 Detection of Radiation



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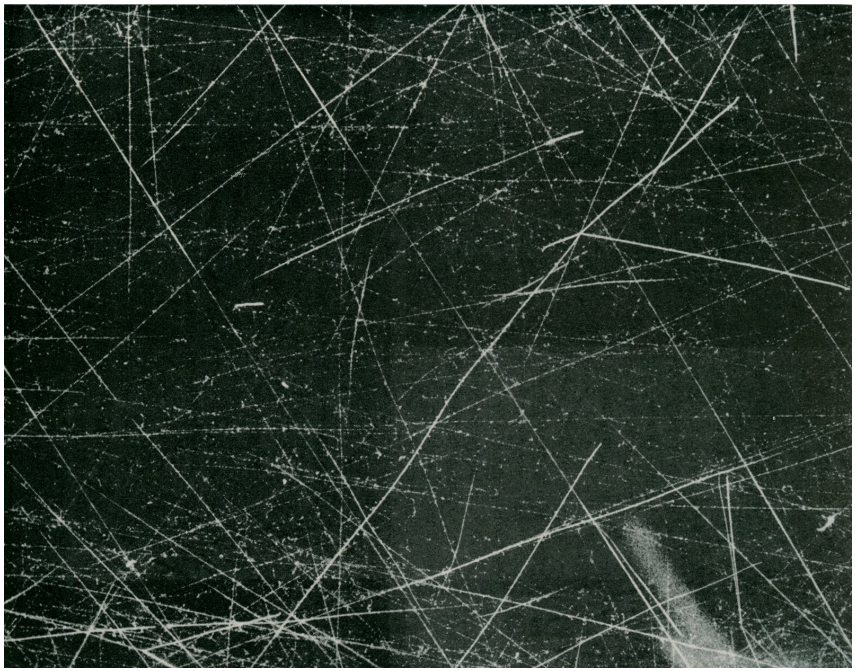
A scintillation counter uses a scintillator – a material that emits light when a charged particle goes through it. The scintillator is made light-tight, and the light flashes are viewed with a photomultiplier tube, which has a photocathode that emits an electron when struck by a photon and then a series of amplifiers.

Cloud Chamber photographs

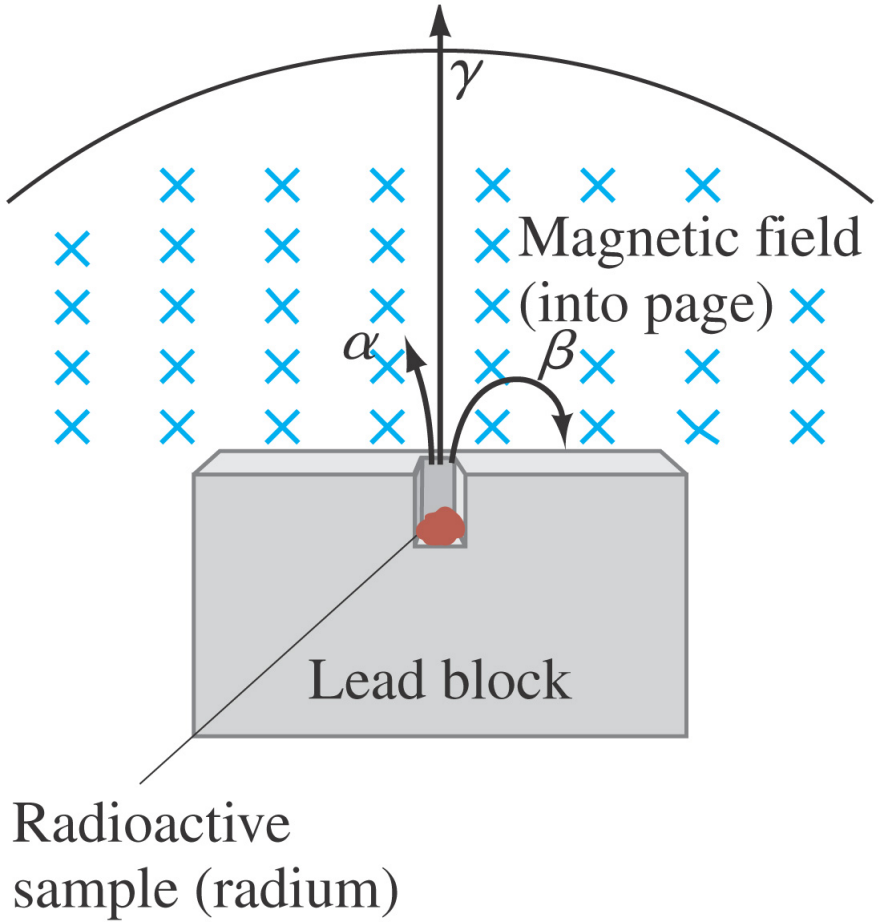


Above: Ionization tracks made by high energy particles.

Right: The addition of a magnetic field causes the particles to form curved, circular, or even spiral tracks.

30.3 Radioactivity

Alpha and beta rays are bent in opposite directions in a magnetic field, while gamma rays are not bent at all.
Remember the Right Hand Rule



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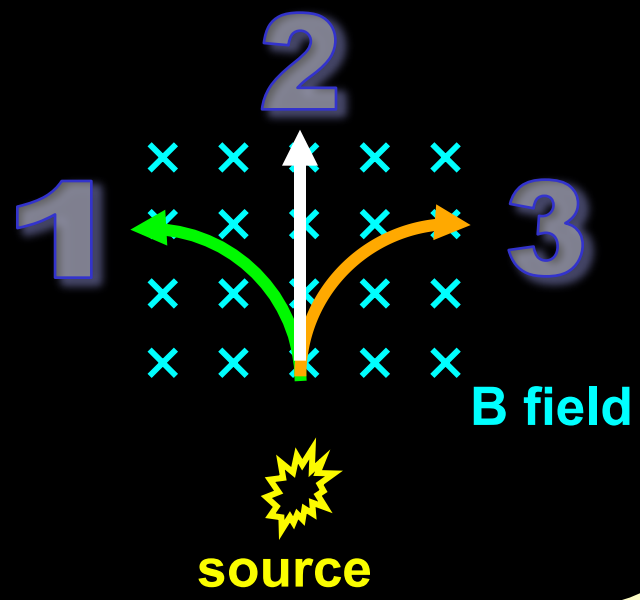
ConcepTest 30.4b Particle Emission II

A radioactive substance decays and the emitted particle passes through a uniform magnetic field pointing into the page as shown.

In which direction are gamma rays deflected?



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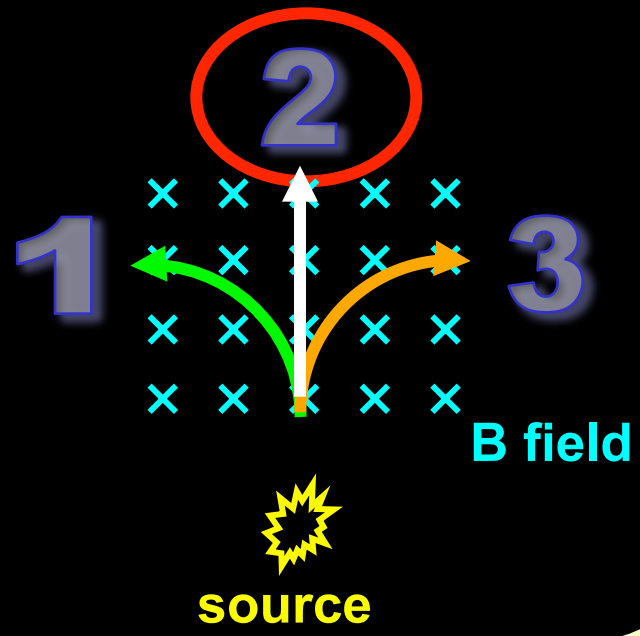
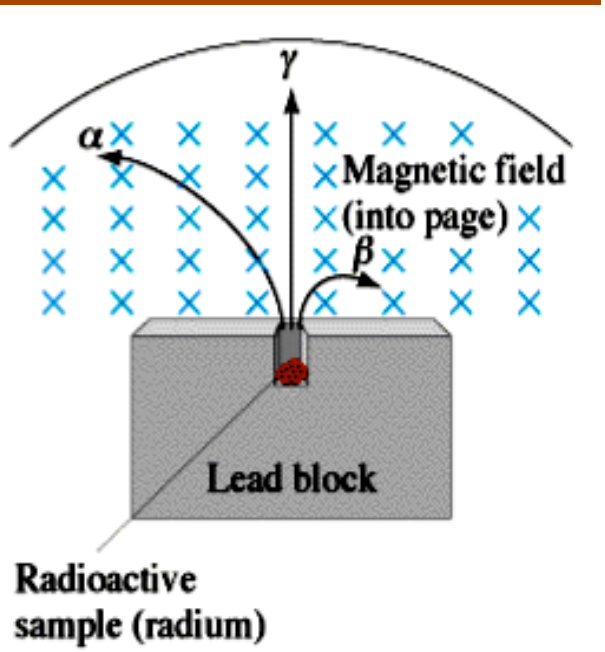
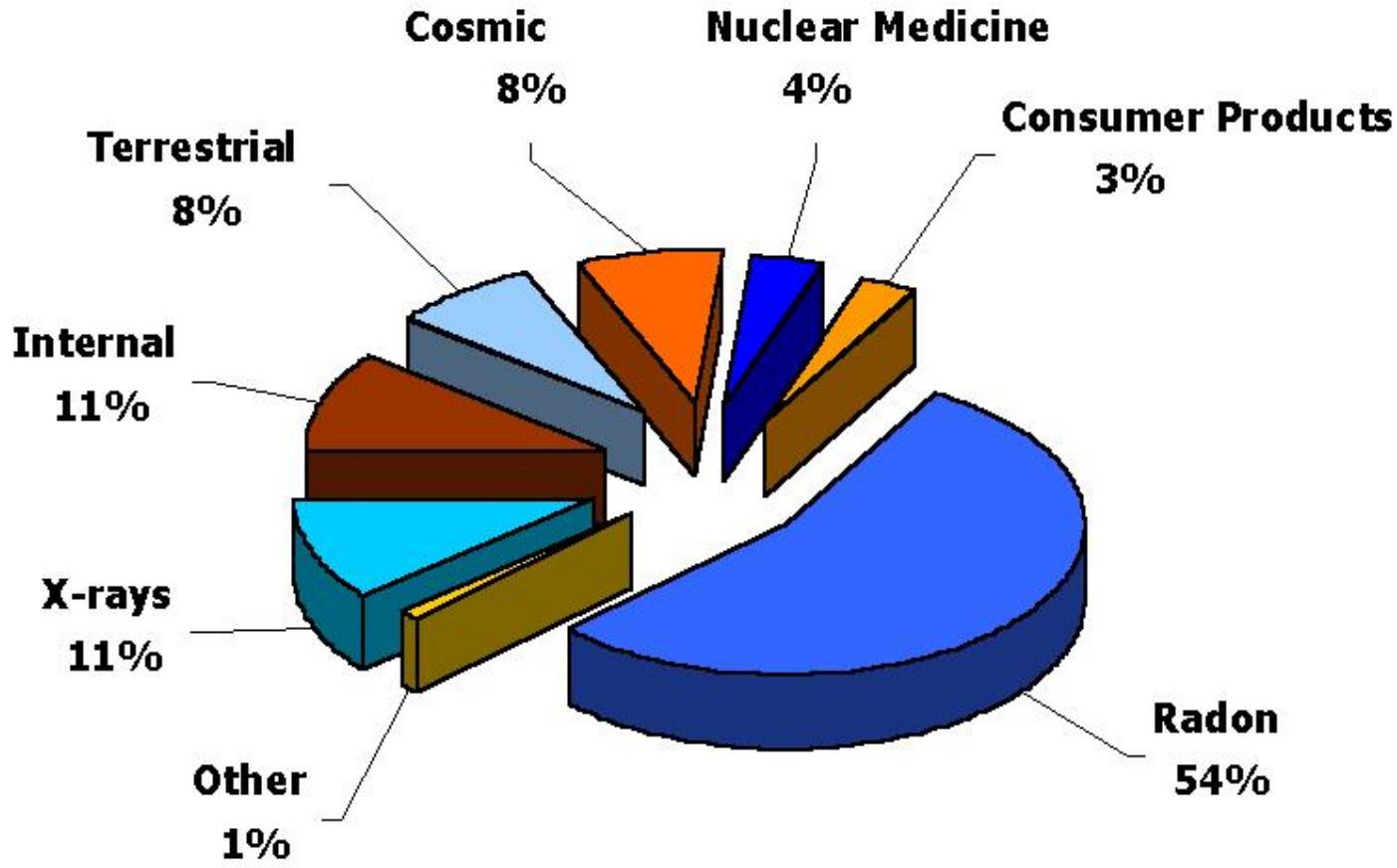


Gamma rays are **uncharged**, so they will **not be deflected** by a magnetic field.

Follow-up: What particles are bent to the right?



Most Nuclear Radiation is Natural



360 mRem/year - U.S. average

Fun facts:

- **The most radioactive thing most of us encounter in a year is a banana.**
- **Your radiation dose from flying in a plane is greater than your dose from the security X-ray scanner at check-in.**