

UNIT 4: NUCLEAR IMAGING

4.3 Radiation detectors

Radiation detectors are devices used to measure and monitor radiation levels, typically in the form of ionizing radiation such as alpha particles, beta particles, gamma rays, or neutrons. These detectors are critical in a variety of fields, including nuclear power, medicine, environmental monitoring, and research. Below are common types of radiation detectors and their applications:

Types of Radiation Detectors

1. Gas-Filled Detectors

These detectors use ionized gas to detect radiation:

- **Geiger-Müller (GM) Counters:**

- Detect beta particles, gamma rays, and x-rays.
- Widely used for general-purpose radiation monitoring.
- Affordable and portable, but less sensitive for high-energy gamma radiation.

- **Ionization Chambers:**

- Measure radiation dose in a gas-filled chamber.
- Common in medical and industrial settings for precise dose measurement.

- **Proportional Counters:**

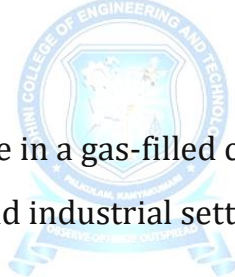
- Similar to GM counters but provide energy information about detected particles.
- Used in spectroscopy.

2. Scintillation Detectors

- Use scintillating materials (e.g., sodium iodide or plastic) that emit light when exposed to radiation.
- Coupled with photomultiplier tubes (PMTs) or photodiodes to convert light into electrical signals.
- Applications: Medical imaging, radiation safety, and environmental monitoring.

3. Semiconductor Detectors

- Made of materials like silicon or germanium, where radiation produces charge carriers.
- Types:



- **Silicon Detectors:** Detect alpha and beta radiation.
- **High-Purity Germanium Detectors (HPGe):** Used for gamma-ray spectroscopy due to high resolution.
- Applications: Research, spectroscopy, and precise measurement of energy spectra.

4. Neutron Detectors

- Detect neutrons indirectly through secondary reactions (e.g., helium-3 or boron-10 detectors).
- Common in nuclear facilities and research.

5. Thermoluminescent Detectors (TLDs)

- Measure accumulated radiation dose over time.
- Store energy from radiation and release it as light when heated.
- Used in personal dosimetry.

6. Solid-State Dosimeters

- Compact and use direct readouts to measure radiation dose.
- Popular in wearable personal radiation monitors.

Applications of Radiation Detectors

1. Medical Field

- CT scans, PET scans, and radiation therapy.
- Dosimetry ensures patient and staff safety.

2. Nuclear Power Plants

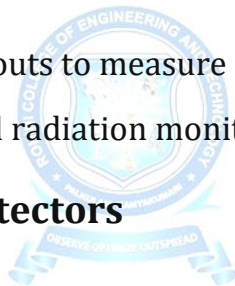
- Monitoring radiation levels in reactors and surrounding environments.
- Ensuring compliance with safety standards.

3. Environmental Monitoring

- Detecting contamination in soil, water, and air.
- Used during nuclear accidents or for radioactive waste management.

4. Homeland Security

- Screening for radioactive materials at borders and in public spaces.
- Detecting illicit transport of nuclear materials.



5. Scientific Research

- Particle physics experiments and radiation measurements.
- Studying cosmic rays and other astrophysical phenomena.

6. Industrial Applications

- Checking material density, thickness, or composition using radiation.
- Non-destructive testing.

Key Considerations for Choosing a Detector

- Type of radiation (alpha, beta, gamma, neutrons).
- Sensitivity and energy resolution requirements.
- Portability and durability.
- Environmental conditions (e.g., temperature or humidity).

