Radiation Detection Principles

How do we detect radiation?

Radioactive materials emit one or more of the four basic types of radiation – alpha, beta, gamma and neutron

Radiation cannot be detected with human senses (touch, smell, taste, sight, hearing)

As such, special instrumentation is required to detect radiation

Detection Basics

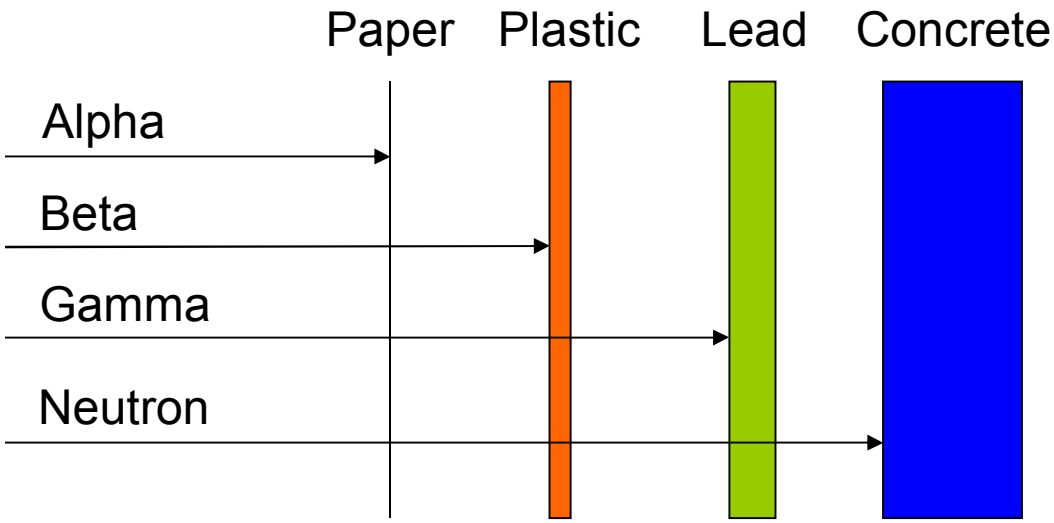
Visual
Audio
Tone
Vibrate

Radioactive Material Emits Radiation

Instrument Detects Radiation

Electronics Converts to Readout

Effects of Shielding



For detection of radioactive materials, only gammas and neutrons have sufficient energy to penetrate shielding materials and travel 10's to 100's of meters in air

Instrument Selection

Base your instrument selection on what you are looking for:

- Radiation (dose)
- Contamination (removable)
- Radioactive Material
- Radionuclide Identification
- Airborne Radioactive Material

Detection Instruments

Radiation detection instruments can be divided into three primary categories:

- Radiation search, survey and portal monitoring
- Radioactive material identification
- Dose monitoring and radiation contamination survey

Each detector is designed to detect a certain type of radiation

Overview of Radiation Detectors

Radiation Search, Survey and Portal Monitoring

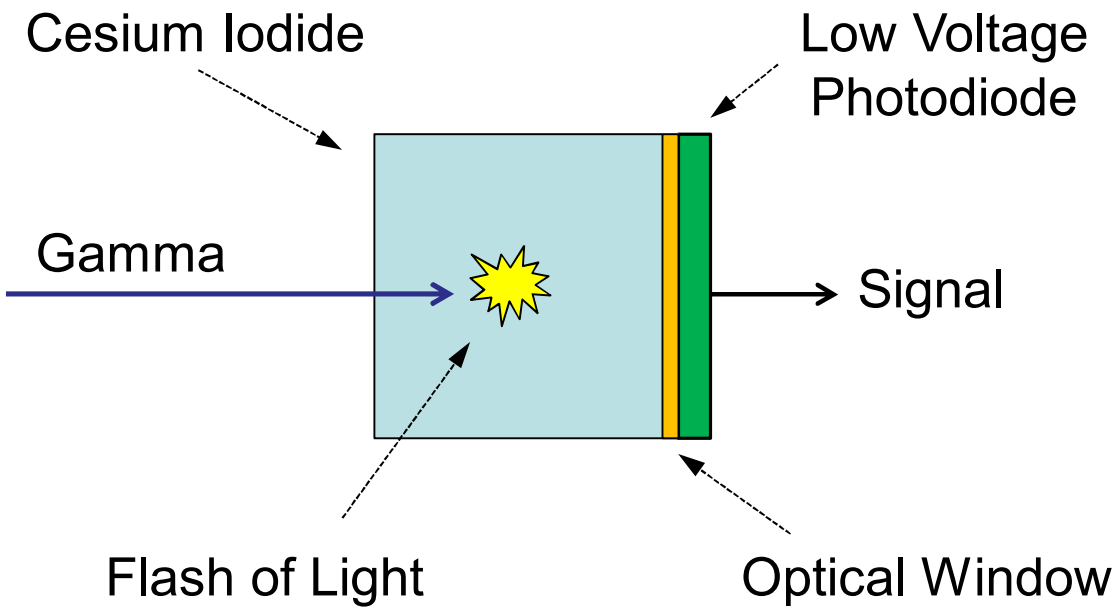
Determine if a radiation source is present and, if so, is it a potential health hazard

Reason for Search, Survey and Portal Monitoring

Why conduct searches, surveys and monitoring?

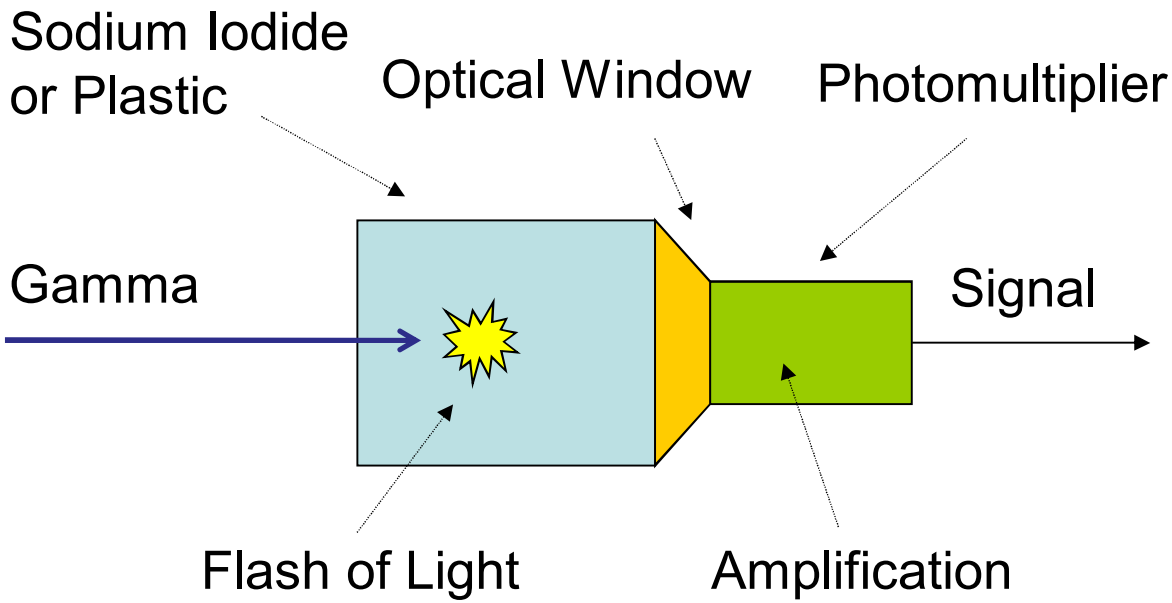
- Search for lost or stolen radioactive materials
- Baseline surveys to ensure area free of radioactive materials
- Roadblock portal monitors for scanning cargo containers at shipping ports and railways
- Portal monitors for vehicle inspections at border crossings

Scintillation Gamma Detector (with Photodiode)



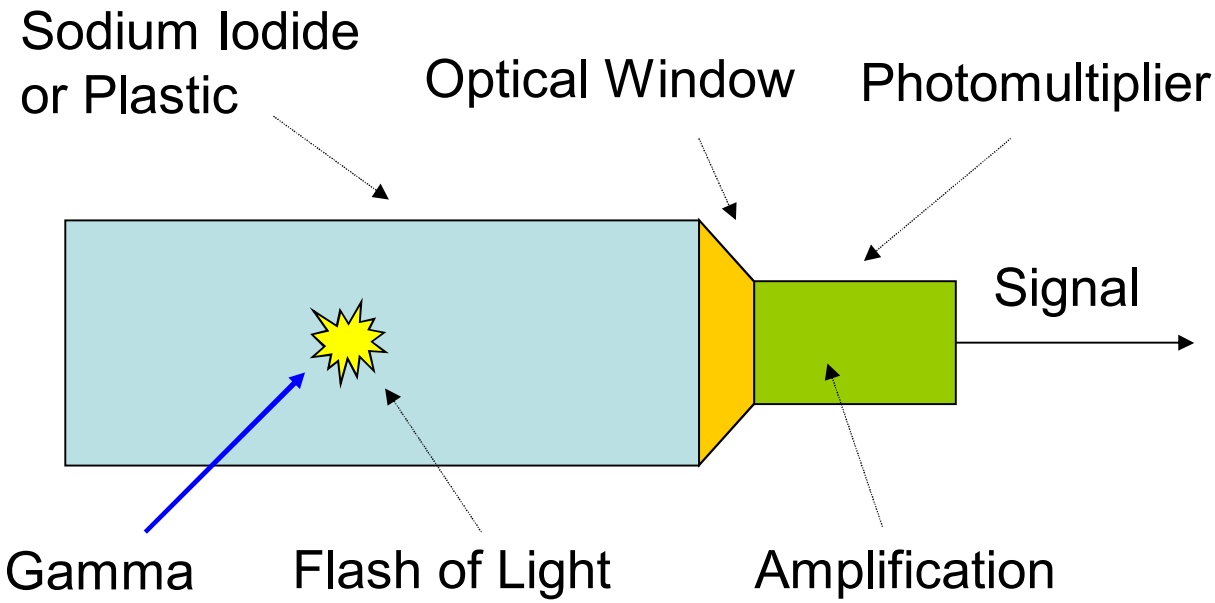
Small/compact detectors with low voltage for pagers

Scintillation Gamma Detector (with Photomultiplier)



Medium size detectors for handheld meters and backpacks

Scintillation Gamma Detector (with Photomultiplier)



Large size detectors for mobile systems and portal monitors

Large Radiation Portals

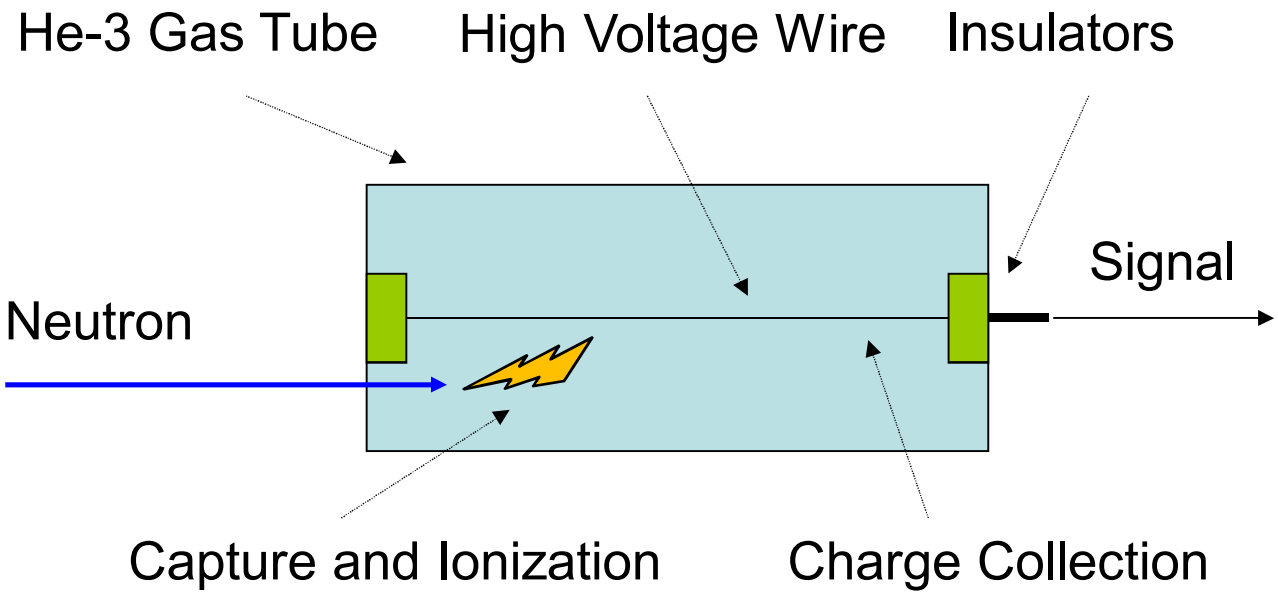
Large radiation portals primarily use plastic scintillators instead of sodium iodide for gamma detection

Advantages:

Larger sizes
Lower costs
Less sensitive to temperature variations

Plastic can be produced in large panels for high sensitivity

Helium-3 Neutron Detector



Small and large tubes for wide range of detection systems

Large Radiation Portals

Large radiation portals use Helium-3 detectors for neutron detection

Available in longer tubes
Typical 3-6 feet (1-2 meters)
Multiple detectors in an array with polyethylene moderator

Can be produced in large arrays for high sensitivity

Overview of Radiation Detectors

Radioactive Material Identification

Determine the identification of the radioisotope causing the radiation alarm

Identification of the radioisotope is needed to evaluate the hazard

Reason for Identification

Why conduct radionuclide identification?

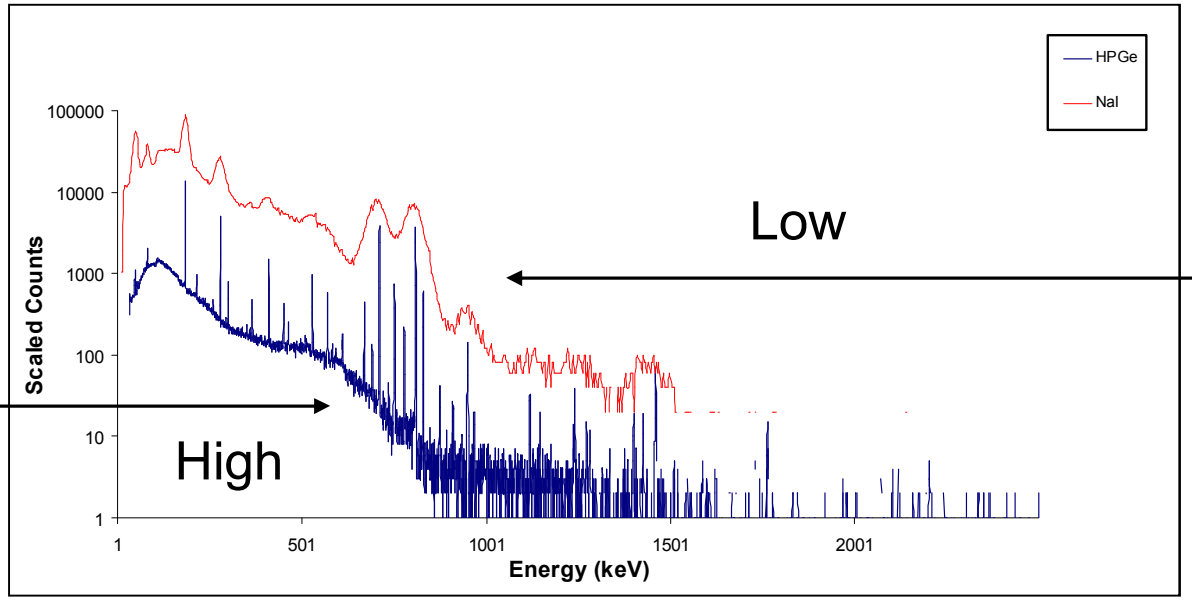
- By using gamma energy spectroscopy, one can identify the radioisotope(s) causing the alarm
- Can aid in adjudicating the alarm – ***each radioisotope has a unique gamma energy spectrum or "fingerprint"***
- Can determine if the cargo is consistent with the manifest
- Gives an indication of the problem and allows us to better control and understand the potential hazard

Radioisotope Identification

High Resolution vs Low Resolution Gamma Spectroscopy

Resolution - "ability to resolve adjacent gamma peaks"

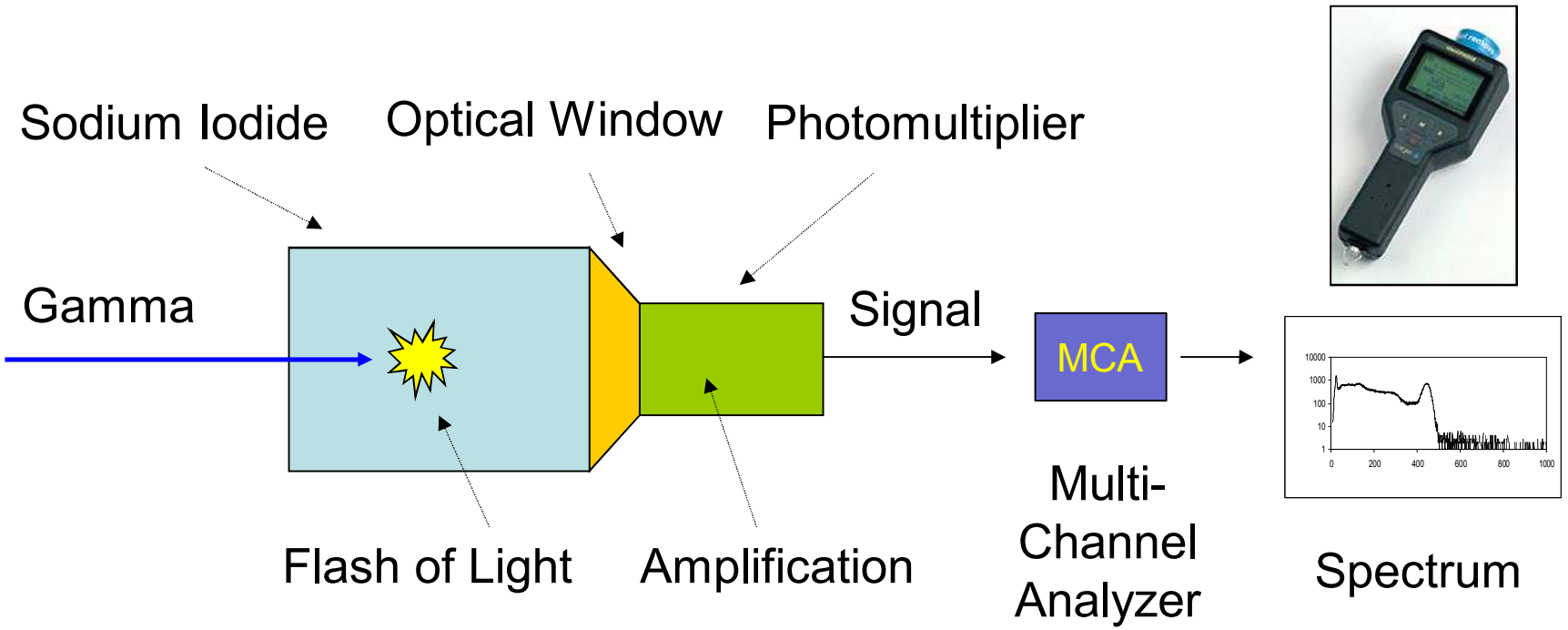
HPGe



NaI

Sodium iodide (NaI) is used for ***"Screening"***
High purity germanium (HPGe) is used for ***"Identification"***

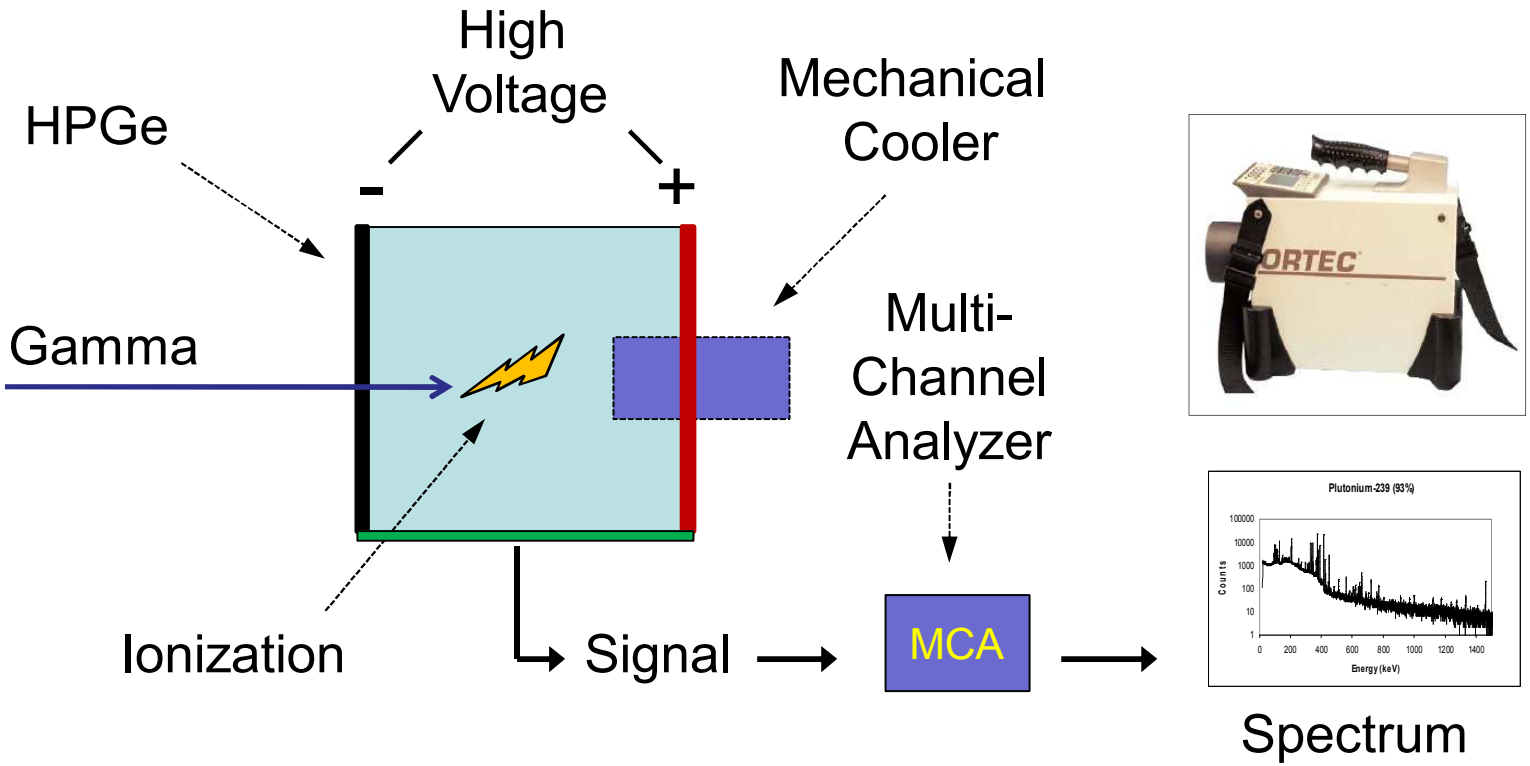
Scintillation Gamma Detector (with Photomultiplier)



Low resolution detector for radioactive material "Screening"

RadioIsotope IDentifier (RIID)

High Purity Germanium (HPGe) Gamma Detector



High resolution detector for radioactive material "Identification"

Overview of Radiation Detectors

Dose Monitoring and Radiation Contamination Survey

Determine dose rate to assess safety risk and determine if there is radiation contamination and if it has spread

Reason for Dose Monitoring

Why monitor for radiation dose?

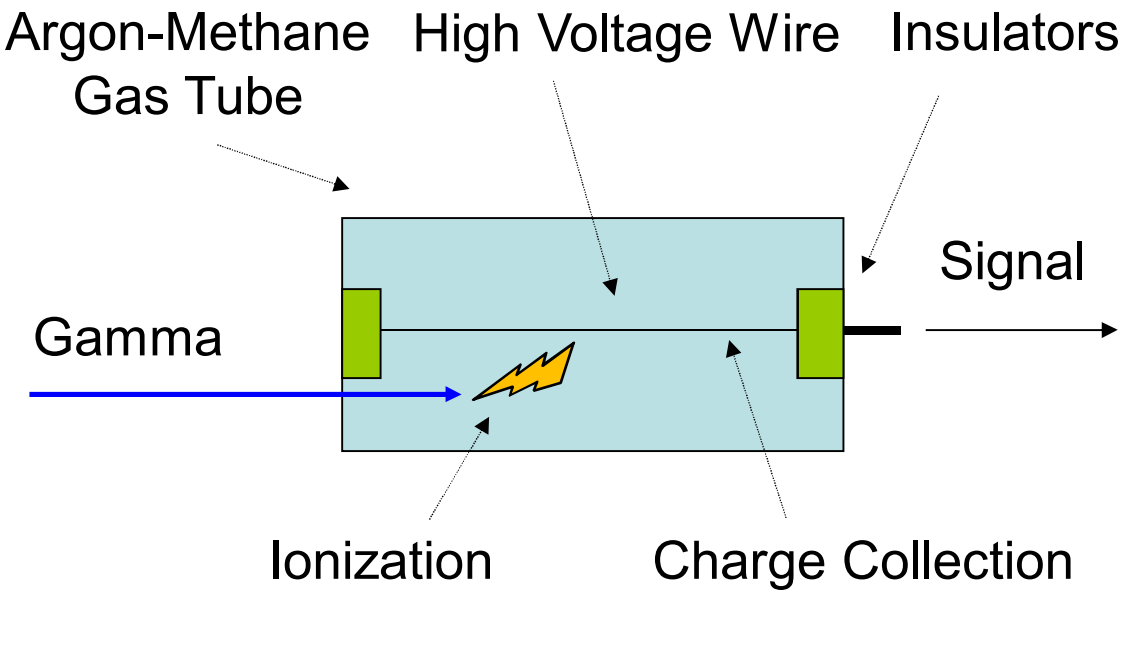
- Determine if radiation source poses a health risk
- Allow for planning to minimize dose
- Determine stay times and turn back levels
- Provide a record of individual's total dose received

Dose Monitoring

Dose monitoring instruments include:

- Dose rate meters to measure gamma dose rate (Sv/h)
- Alarming dosimeters to measure an individual's gamma dose as well as alarm when the dose rate (Sv/h) or total dose (Sv) thresholds are exceeded
- Dosimetry instruments are for health monitoring and require periodic calibration to a known standard

Geiger-Mueller Detector



Small "peanut size" detectors with high dose range for dose rate meters and alarming dosimeters

Reason for Survey

Why survey for contamination?

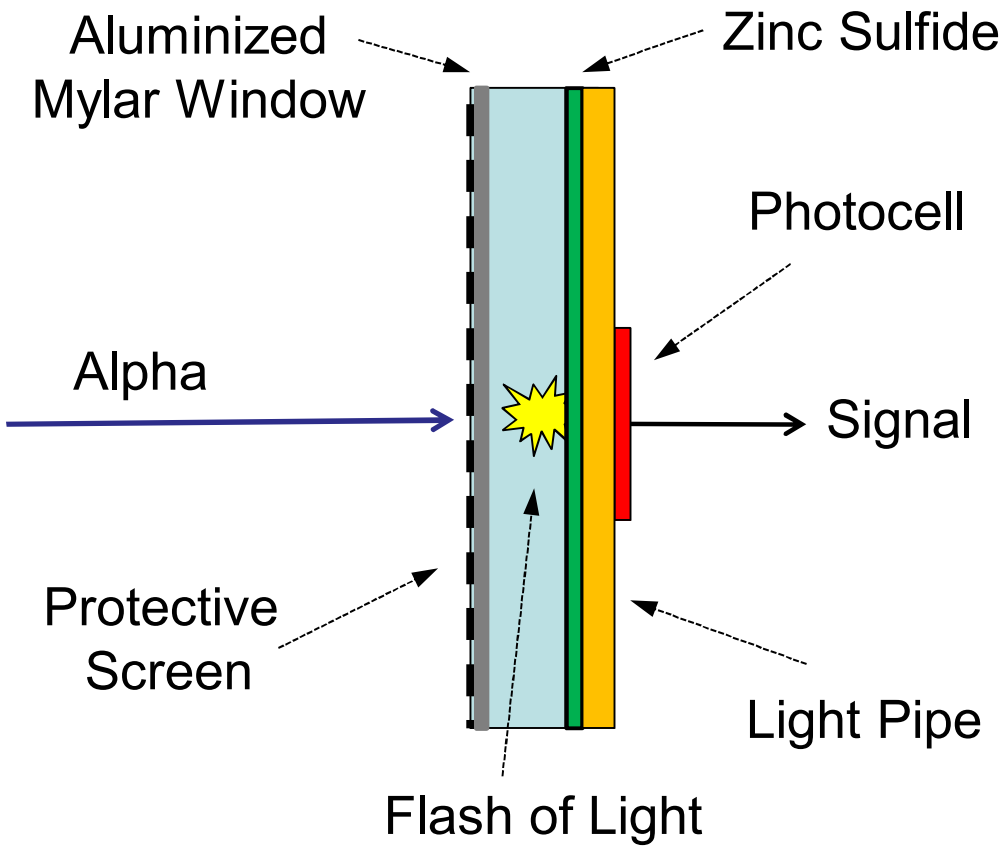
- Determine the loose and fixed concentration of radioactive material
- Determine methods to control the spread of contamination
- Determine methods to limit the amount of radioactive material entering the body
- Determine the level of Personal Protective Equipment (PPE)

Reason for Survey

Is it an alpha and/or beta emitter?

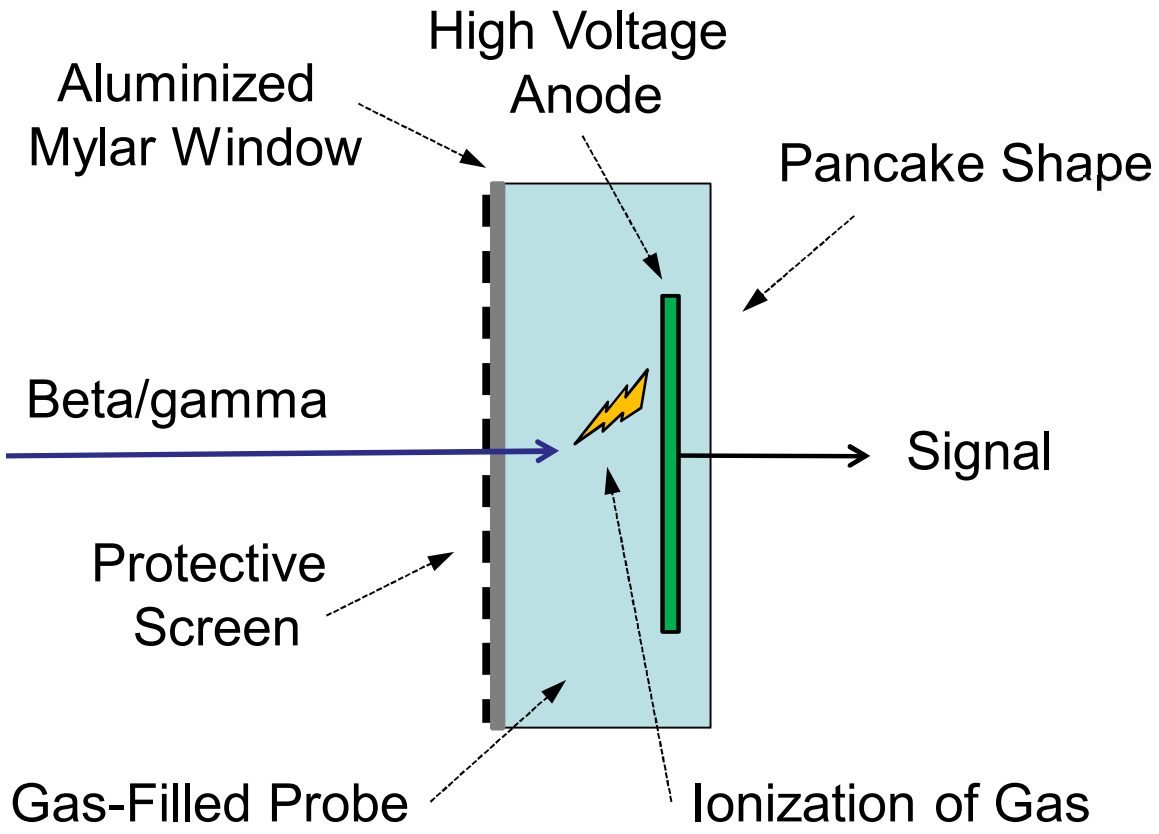
- By determining if the radioactive material is not emitting alpha particles, eliminates an entire class of radionuclides
- By determining if the radioactive material is not primarily emitting beta particles, eliminates an entire class of radionuclides

Alpha Scintillation Probe



Large surface area probe for surveying for alpha contamination

Beta/Gamma Pancake Probe



Pancake probe for surveying for beta/gamma contamination

Summary

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