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Title: Ship Effect- Issues with Radiation Detection Aboard Ships

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Ship Effect

- Issues with Radiation Detection Aboard Ships

Lesson Objectives

1. Understand issues with neutron radiation aboard ships.
2. Understand issues with gamma radiation spectra collection aboard ships.

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Neutrons

- **Not often observed in nature**
 - Low background
 - Alarm techniques can be very sensitive
- **Usually correlated with SNM**
- **Not well-shielded by steel**
 - May be the predominant signal of a threat
- **Well moderated by hydrogenous materials**

Sources of Neutrons

- **Fission**

- When uranium or other fissionable material fissions, the atom fragments, creating fission fragments, and releasing about $2 \frac{1}{2}$ neutron per fission – which can cause other fissions.
 - Spontaneously
 - Induced fission

- **Alpha-n**

- When an alpha particle interacts with a nucleus a neutron can be releases
- For many low Z materials

- **Fusion**

- Neutron generator
- Deuterium is accelerated to Tritium target or vice versa
 - 14 MeV neutrons
 - Needs electric power to cause the acceleration
 - D-D generator 2.45 MeV

Cosmic Particles

- **High energy particles travel through the cosmos**
 - Protons (90%), alpha particles (9%), other heavy ions
 - Tremendous energy (GeV – 10^3 MeV, TeV 10^6 MeV)
 - 1 GeV $10^4 \text{ m}^{-1} \text{ s}^{-1}$, 1 TeV $1 \text{ m}^{-1} \text{ s}^{-1}$ at surface of atmosphere
- **Interact with materials on Earth**
 - Create showers of gammas, pions, muons, protons, and neutrons
 - Primary particles $< 1 \text{ GeV}$ stopped in atmosphere

Shower

From Report Number 5 of the [Scientific Report Series](#) of the [Aurora Research Institute](#). Copyright Aurora College, April 1996.

What It Looks Like Up Close

Photomicrograph showing the track of a cosmic ray impact

Cosmic Particle Flux

- **Solar cycle**
 - Roughly 11 year cycle
 - Highest at solar minimum
- **Altitude**
 - Not much of an issue with ships
- **Position on earth**
 - Magnetic field doesn't shield particles near poles
- **Barometric pressure**
 - Density of air neutron flux

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Effect of Cosmic Rays

So What Does This Mean?

- **Going to a ship**

- Sea level, lots of water around, is neutron count high or low?
- Getting near the ship – neutron count?
- Going around the ship – neutrons high, low, steady?

- **Aboard**

- On deck – high, low, steady?
- Initially below decks – higher, lower, same?
- As you descend – increasing, decreasing, same?
- As you transit horizontally – be mindful of superstructure
- As you pass rooms – repeatable increases?
- Be mindful of hydrogenous sources that moderate neutrons

Gamma Spectra on Ships

- Where does natural gamma background come from?
 - NORM
 - Cosmic sources
 - Mostly NORM
 - K-40 – Living things (or formerly living)
 - Th-232 – varies with geology of minerals
 - U-238 decay chain – Ra-226/Ra-222

So What?

- **Almost no identifiable nuclides in background**
 - So known source becomes vital
- **Lower background levels**
 - Sources are more readily detected
 - UNLESS an alarm threshold is fixed level – then source must be stronger

Typical Background in a Building

- Taken in a Lab at BNL
- Average gamma count rate is 52 cps

Background Near the Water

- Taken on Long Island at the Cross Sound Ferry Terminal (sand spit on the water) – no bedrock
- Average count rate is 26 cps

The Mary Ellen

- Length, 260 ft.; beam, 44 ft, draft, 10 ft.
- Capacity of 85 vehicles

Background Spectrum in the Ferry

- Taken on the vehicle deck of the Mary Ellen, sitting at the dock
- Average count rate is only 5 cps. No visible K-40 or Th-232

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Considerations of Ship Construction and Contents

- **Ships have lots of steel**
 - Compartments tend to be better shielded from each other as compared to rooms in a residence or light commercial building
- **Mechanical spaces are very tightly packed with dense material**
 - Engines, pumps, plumbing, machinery
 - All provide shielding and hiding places
 - Spallation reactions from cosmic rays
- **Cargo is densely packed and can be both shielding and a source.**
 - NORM: ceramics, stone, foreign lumber