Training Outline

- Radiation, Ionization, & Radioactivity
- Radiation Protection & Safety
- Radiation Dose
- Questions ??
Electromagnetic Radiation

<table>
<thead>
<tr>
<th>Ionising Radiation (potentially harmful or beneficial to humans)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cosmic</td>
</tr>
<tr>
<td>High frequency</td>
</tr>
</tbody>
</table>

**THE ELECTROMAGNETIC SPECTRUM**
**Definitions**

- **Radiation**: Energy (electromagnetic waves or particulates)

- **Ionization**: The removal of electrons from an atom

- **Ionizing Radiation**: Particles or rays with sufficient energy to remove electrons from atoms
Ionization

The ionized atom causes changes which **MAY** damage cells, which **MAY** cause health effects.
Ionizing Radiation

- Alpha (α)
- Beta (β)
- Gamma, X-rays (γ)
- Neutrons

Materials:
- Aluminium
- Lead
- Concrete
Atoms & Radioactivity

Most atoms are stable, but some may emit excess energy (radiation) and are called radioactive.
Radiation Sources

Confinement  |  Guide Hall
Radiation Exposure

There are **two ways** that you can be exposed to a radiation source:

1. If the source is *outside the body*, you will receive an **external** exposure.

2. If the source gets *into the body*, you will receive an internal exposure.

Both kinds of exposure are of equal concern, despite subjective feelings to the contrary by many workers.
Reducing External Exposure

PROTECTION METHODS

EXTERNAL EXPOSURE

TIME

DISTANCE

SHIELDING
Always remember that the longer the exposure, the greater the dose, which leads to a greater amount of damage. Thus, your first protective measure should be to minimize the time of exposure.
Distance

The closer you are to a source, the greater your exposure will be.

By decreasing distance by 1/2, exposure increases by 4 times.
Distance – Inverse Square Law

\[ \text{RADIATION INTENSITY} \propto \frac{1}{(\text{distance})^2} \]
Shielding can be used to reduce your exposure to sources of radiation.

Increasing the amount of shielding will decrease your amount of exposure.
Internal Exposure

Sources can enter the body in four ways:

A. INGESTION  (EATING OR DRINKING)
B. INHALATION  (BREATHING)
C. ABSORPTION  (THROUGH THE SKIN)
D. INJECTION

Once in the body, it is very difficult to remove a source of exposure.
Campfire Analogy

- Airborne Activity
- Radiation
- Radioactive Material
- Contamination
Radiation Dose Units

Dose Units are known as the **rad** and **rem**

**rad** = the amount of energy absorbed in tissue

**rem** = relates the amount of ionization in air (R) or the amount of absorbed energy (rad) to the degree of biological damage

<table>
<thead>
<tr>
<th>Radiation Type</th>
<th>Quality Factor (QF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray</td>
<td>1</td>
</tr>
<tr>
<td>Gamma rays</td>
<td>1</td>
</tr>
<tr>
<td>Beta particles</td>
<td>1</td>
</tr>
<tr>
<td>Neutrons</td>
<td>3-10</td>
</tr>
<tr>
<td>Alpha particles</td>
<td>20</td>
</tr>
</tbody>
</table>
Average Background Dose

US Average ~ 360 mrem/yr
Denver, CO ~ 700 mrem/yr
Brazil (beaches) ~ 5,000 mrem/yr
Health Physics Labels/Signs

>5 mrem/hr (whole body dose)

>100 mrem/hr (whole body dose)

~100,000 mrem/hr (localized dose)

CAUTION
High Radiation Areas in the beams in this room are designated by:
NEUTRON BEAM No Entry
Contact Health Physics for additional information.
General Public Dose
Limit = 100 mrem/yr

Occupational Dose
Limit = 5,000 mrem/yr
Radiation Dose and Risk

Observed Effects
Assumed Relationship

Effect

low
high

Radiation Dose

50,000 millirem
<table>
<thead>
<tr>
<th>Activity</th>
<th>Cause of Death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking 1 cigarette</td>
<td>Cancer, Heart Disease</td>
</tr>
<tr>
<td>Travel 50 miles by car</td>
<td>Fatal Accident</td>
</tr>
<tr>
<td>Drinking 30 cans of diet soda</td>
<td>Cancer (saccharin)</td>
</tr>
<tr>
<td>Eating 100 grilled steaks</td>
<td>Cancer (benzopyrene)</td>
</tr>
<tr>
<td>Chest X-ray (10 mrem)</td>
<td>Cancer</td>
</tr>
</tbody>
</table>

*Performing this activity increases your chance of dying by one in a million (1 x 10^-6)*
## Loss of Life Expectancy

<table>
<thead>
<tr>
<th>Cause</th>
<th>Life Lost (time)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking 20 cigarettes a day</td>
<td>6 years</td>
</tr>
<tr>
<td>Overweight (by 15%)</td>
<td>2 years</td>
</tr>
<tr>
<td>Alcohol consumption (U.S. average)</td>
<td>1 year</td>
</tr>
<tr>
<td>Agricultural accidents</td>
<td>320 days</td>
</tr>
<tr>
<td>Construction accidents</td>
<td>227 days</td>
</tr>
<tr>
<td>Auto accidents</td>
<td>207 days</td>
</tr>
<tr>
<td>Home accidents</td>
<td>74 days</td>
</tr>
<tr>
<td>Occupational radiation dose (1 rem/y)</td>
<td>51 days</td>
</tr>
</tbody>
</table>
Ionizing Radiation - Overview

**Can not see it, feel it, or smell it**
- we must rely on training and equipment to protect ourselves

**Relatively simple to detect and measure**
- unlike chemical and biological hazards
- we can quickly assess and take action

**Biological effects have been intensely studied for 50 years**