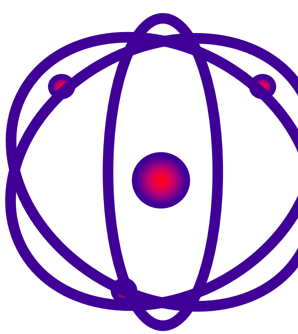
Ionizing Radiation Training



Objectives:

- What is ionizing radiation
- Describe different forms
- Review radiation measurement units
- List natural and man-made sources
- Review regulatory guidelines
- Describe hazards and potential health effects
- Describe how low doses are maintained
- List employee responsibilities
- Review sources of radiation information

Introduction

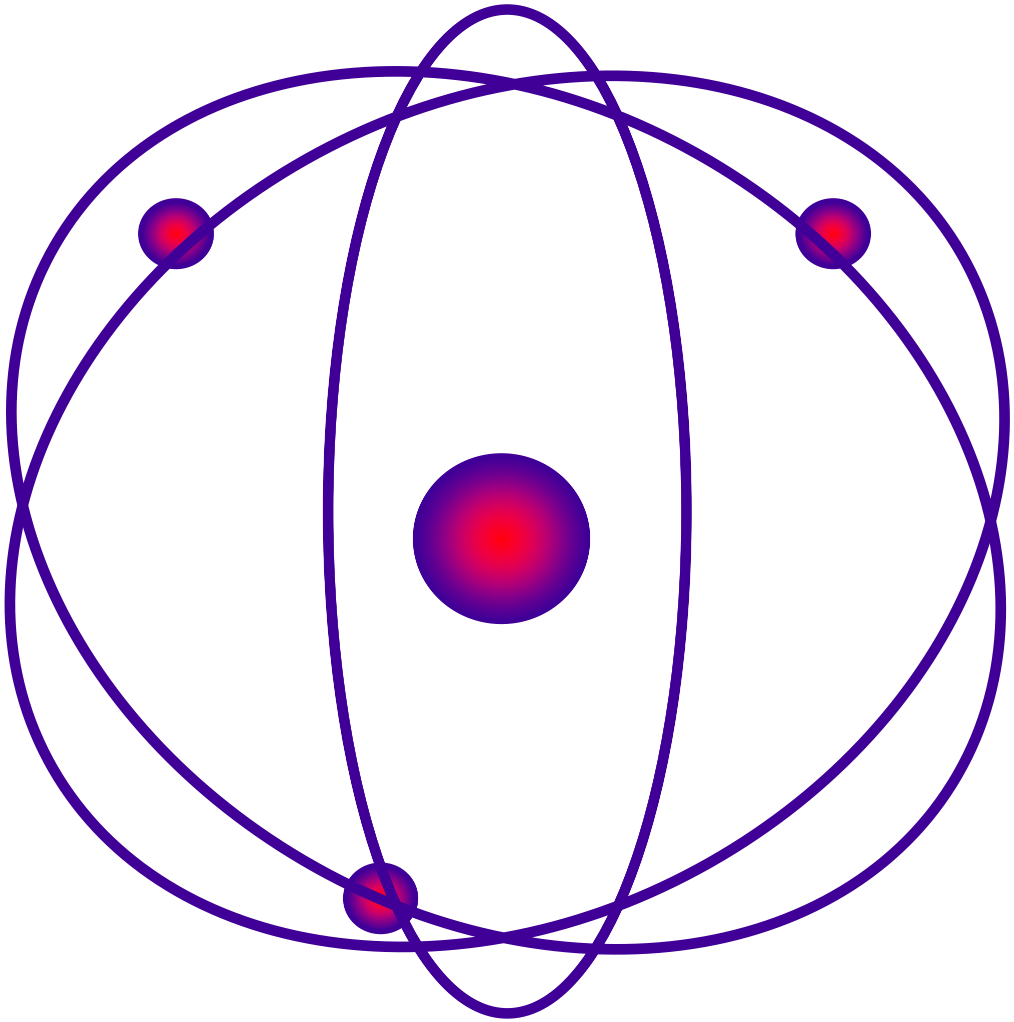
- Radiation --> general term referring to the emission and propagation of energy by means of electromagnetic or subatomic particles
- Includes:
  - radiowaves
  - microwaves
  - heat
  - visible light
  - ultraviolet light

Non-ionizing Radiation

- Excessive exposure to non-ionizing radiation may also have harmful effects

Introduction

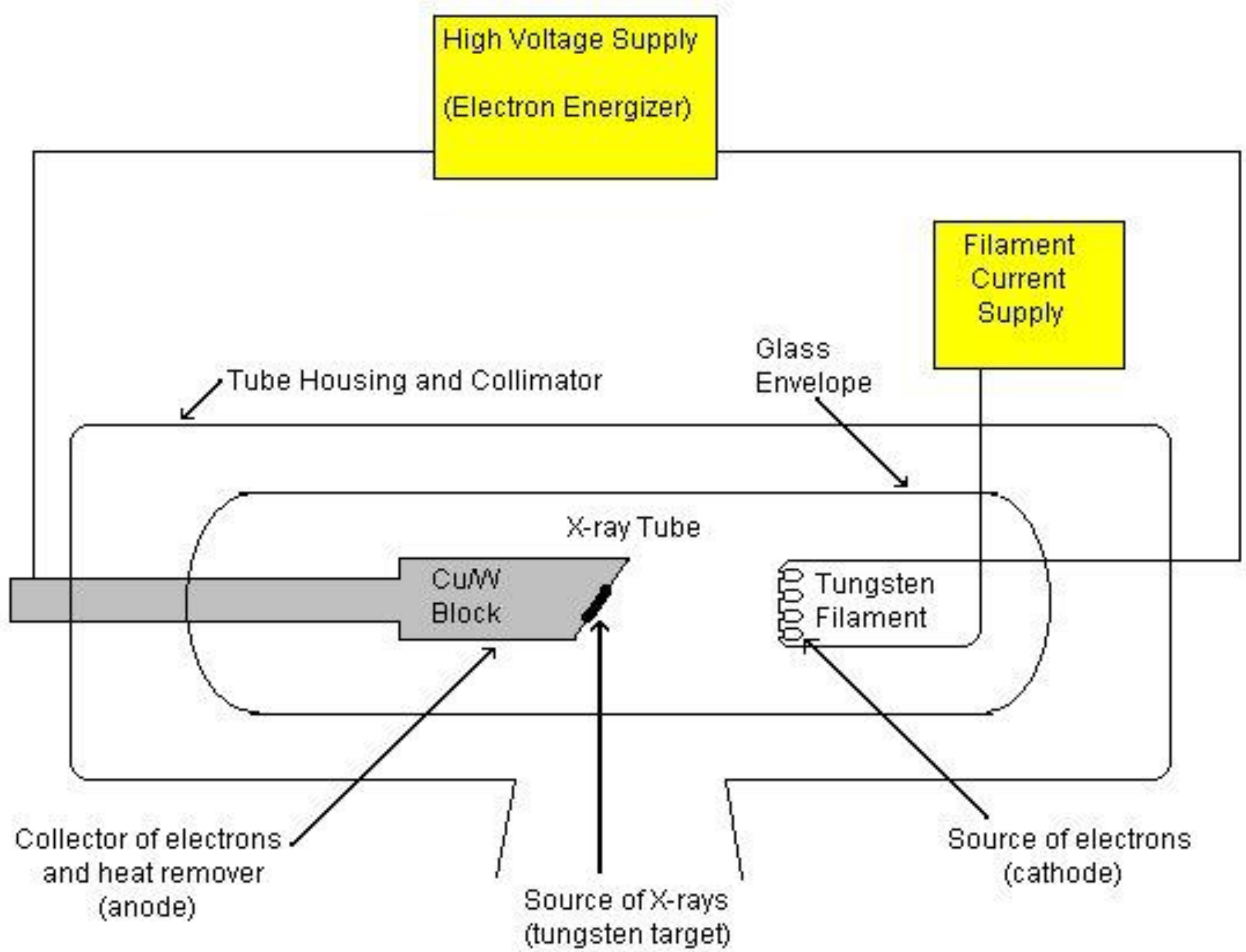
- Ionizing radiation is any electromagnetic or particulate radiation with sufficient energy to ionize or remove electrons from their atomic orbits
- Atomic structure:
  - protons
  - neutrons
  - electrons



Forms of Ionizing Radiation

- Directly Ionizing Radiation
  - alpha and beta sealed sources
  - small travel distance and minimal penetration
  - no external hazard
- Indirectly Ionizing Radiation
  - X-rays and gamma rays
  - uncharged particles, deeply penetrating
  - shielding important

Components of an X-ray Machine

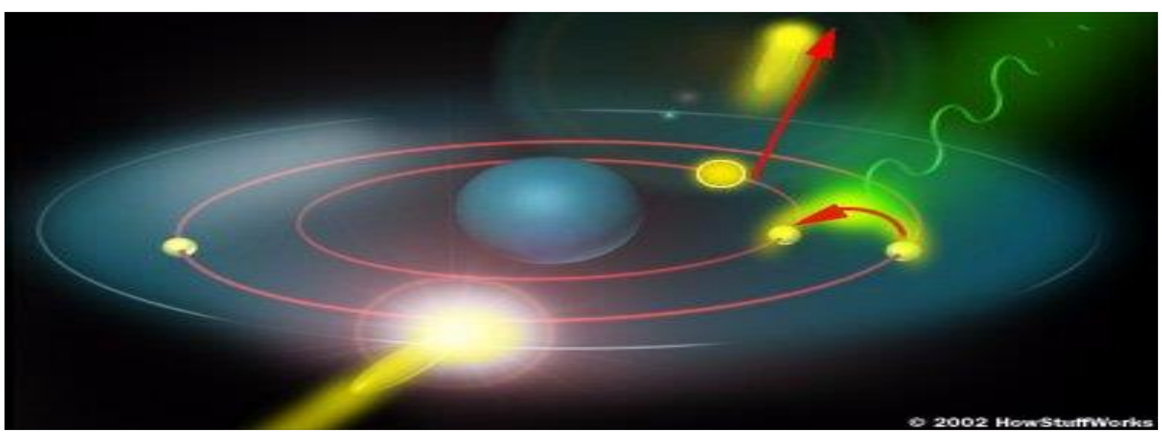


Physics of X-ray Production

- Source of Electrons
  - Tungsten filament - cathode (negative)
  - Heated to release electrons
  - Number of electrons proportional to temperature
  - Milliampere (mA) control adjusts heating current
  - Voltage (kVp) provides energy
- Target
  - Tungsten block on copper stem - anode (positive)
  - Attracts negatively charged electrons
  - Convert kinetic energy of electrons into x-ray photons

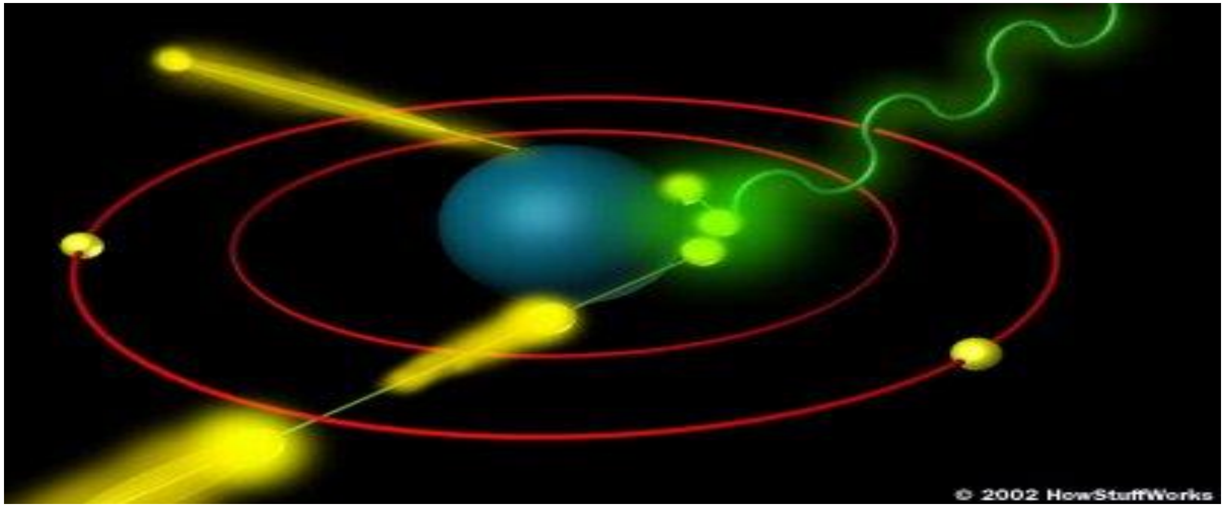
Physics of X-ray Production

- Activity at Target by Projectile Electrons
  - Interact with outer orbital electrons
    - excitation ---> heat (>99% of electrons)
  - Interact with innermost orbital electrons
    - eject electron ---> outer orbital electron drops down to inner orbit ---> x-ray photon created
    - characteristic x-rays - discrete energy



Physics of X-ray Production

- Activity at Target by Projectile Electrons
  - Passes close to nucleus causing violent acceleration and change of direction
    - emission of energy ---> x-ray photons (spectrum)
  - leads to loss of kinetic energy and electron slows down (Bremsstrahlung - braking radiation)



Radiation Units

- With x-rays, the main descriptive units are:
  - Dose equivalent
    - radiation's affects on living tissue
    - measured in Sieverts (Sv) or Rems
    - 1 Sievert = 100 Rems
    - normally use microsievert and millirem
    - 10 microsievert = 1 millirem
  - Exposure
    - number of ionizations per mass of air
    - Roentgen, approximately equal to rem
    - easily measured by Geiger Counter

Natural Sources of Radiation

- Sun and Stars
  - essentially huge fusion reactors
  - generate all types of radiation - gamma
- Earth
  - uranium and thorium and their decay products
  - carbon (C-14) and potassium (K-40)
- Human Body
  - Significant quantities of C-14 and K-40
  - Dietary intake
- Total natural radiation of about 125-200 mRem per year

Man-Made Sources of Radiation

- Medical
  - Diagnostic X-rays, cancer treatment, nuclear medicine
- Industrial
  - Radiography, process controls
- Consumer Products
  - Smoke detectors, jewelry, dishes, watches, CRTs
- Others
  - Fallout, building material, air travel

What is the difference between man-made and natural radiation?

What is the difference between man-made and natural radiation?

- **Nothing … they are the same thing.**

Radiation Standards

- New York State Regulations
  - State Sanitary Code, Chapter 1, Part 16
  - Code Rule 38 – Ionizing Radiation Protection
- Maximum Exposure Standards
  - Whole Body = 5 Rems/year = 0.05 Sv/year
  - Lens of eye = 15 Rems/year = 0.15 Sv/year
  - Skin & Extremities = 50 Rems/year = 0.5 Sv/year
  - Declared pregnant woman or those under the age of 18 = 10% of dose = 0.5 Rems/year = 0.005 Sv
- Cortland levels (background) - < 0.05 mR/hour
- No occupational whole body exposure

Hazards of Ionizing Radiation

- Harmful effects are due to its ability to produce ionization in the material through which it passes or to knock electrons out of orbit
- Leaves atom with a net positive charge
- Ions participate readily in chemical reactions and may disrupt complex molecules which cells need to survive – may cause cell damage or death

Hazards of Radiation

- Deal with transfers of energy
- Disrupt molecular structure
- Effects normal functioning of cells
- Can result in cell injury or cell death

- However:
  - region affected by single particle is small, damage is insignificant, chance of delayed effects is low
  - so, you want to prevent the consequence of successive particle damage

Effects of Ionizing Radiation

- Genetic Effects
  - Do not appear in the person exposed
- Somatic Effects
  - Early changes: blood cells, nausea, hair loss, burns
  - Late changes: cataracts, sterility, cancer
- Current sources and exposure levels are not large enough to produce these effects

How do we ensure doses remain low?

- ALARA - As Low As Reasonably Achievable
- Radiation Safety Officer (RSO)
- Sources registered, labeled, tracked
- Instruct personnel about:
  - presence of radiation
  - SUNY Cortland Radiation Safety Program and safety protocol
  - applicable parts State Sanitary Code (Chapter 1, Part 16 and Code Rule 38)
  - importance of promptly reporting incidents
  - need to report unauthorized radioactive sources and radiation equipment

How do we ensure doses remain low? (cont.)

- Radiation Monitoring
  - Survey meters
    - initial equipment sign off
    - every 6 months
    - after significant maintenance
    - upon request
  - Badges - Due to low X-ray exposures, badges are only issued upon request
- Follow 3 basic concepts of radiation protection:
  - Time/Distance/Shielding

Responsibilities

Department Supervisors or Chairs

- Notify the RSO prior to:
  1) obtaining new radioactive substances or equipment;
  2) moving, transferring, modifying, decommissioning or disposing of radioactive substances or equipment; or
  3) new employees using radioactive substances or equipment.
- Ensure the safe operation of radioactive substances or radiation equipment.
- Report unsafe conditions or situations to the RSO.

Responsibilities (cont.)

Employees

- Training is required:
    1) prior to using radioactive substances or equipment and annually thereafter;
    2) when circumstances involving use and exposure change; and
    3) when it is demonstrated that additional training is necessary.
- Observe safe work practices at all times.
- Store radioactive substances and equipment securely to prevent unauthorized use and access.
- Report unauthorized radioactive substances or radiation equipment to the RSO.

Responsibilities (cont.)

Employees

- Pregnant women and women intending to become pregnant should confer with their physician before working with radioactive substances or radiation equipment.
- Report unsafe conditions or situations to the RSO.
- Complete a SUNY Cortland Employee Injury, Illness, Medical Emergency form (Form WC-1) for injuries or illnesses associated with radioactive substances or equipment.
- Be familiar with the contents and purpose of SUNY Cortland's Radiation Safety Program as well as New York State Sanitary Code (Chapter 1, Part 16) and New York State Code Rule 38.

Radiation Information

- SUNY Cortland’s Radiation Safety Program
- New York State Sanitary Code (Chapter 1, Part 16)
- New York State Code Rule 38
- “Notice to Employees” posting within use areas
- SUNY Cortland’s Radiation Safety Officer

Variation in Cosmic and Terrestrial Radiation in the US. (mrem / year)