X-Ray Safety Training
for Analytical and Cabinet X-ray

Analytical
- X-ray diffraction (XRD)
- X-ray fluorescence (XRF)

Cabinet
- X-ray imaging, non-medical (Faxitron, uCT)
- X-ray tomography

Office of Risk Management
Environmental Health and Safety Department
Radiation Safety Office
541-737-2227
radiation.safety@oregonstate.edu

Introduction

Training for Analytical and Cabinet X-ray users is in 3 parts:

- General awareness (this on-line training module)
  - Nature of x-rays and hazards
  - Radiation protection
  - Regulations
  - Documented on Radiation Safety Form 108
- Quiz (a link to the quiz is at end of this training)
- Lab-based Machine Specific Training
  - Required for each x-ray machine
  - Contact machine administrator
  - Documented on form 108C

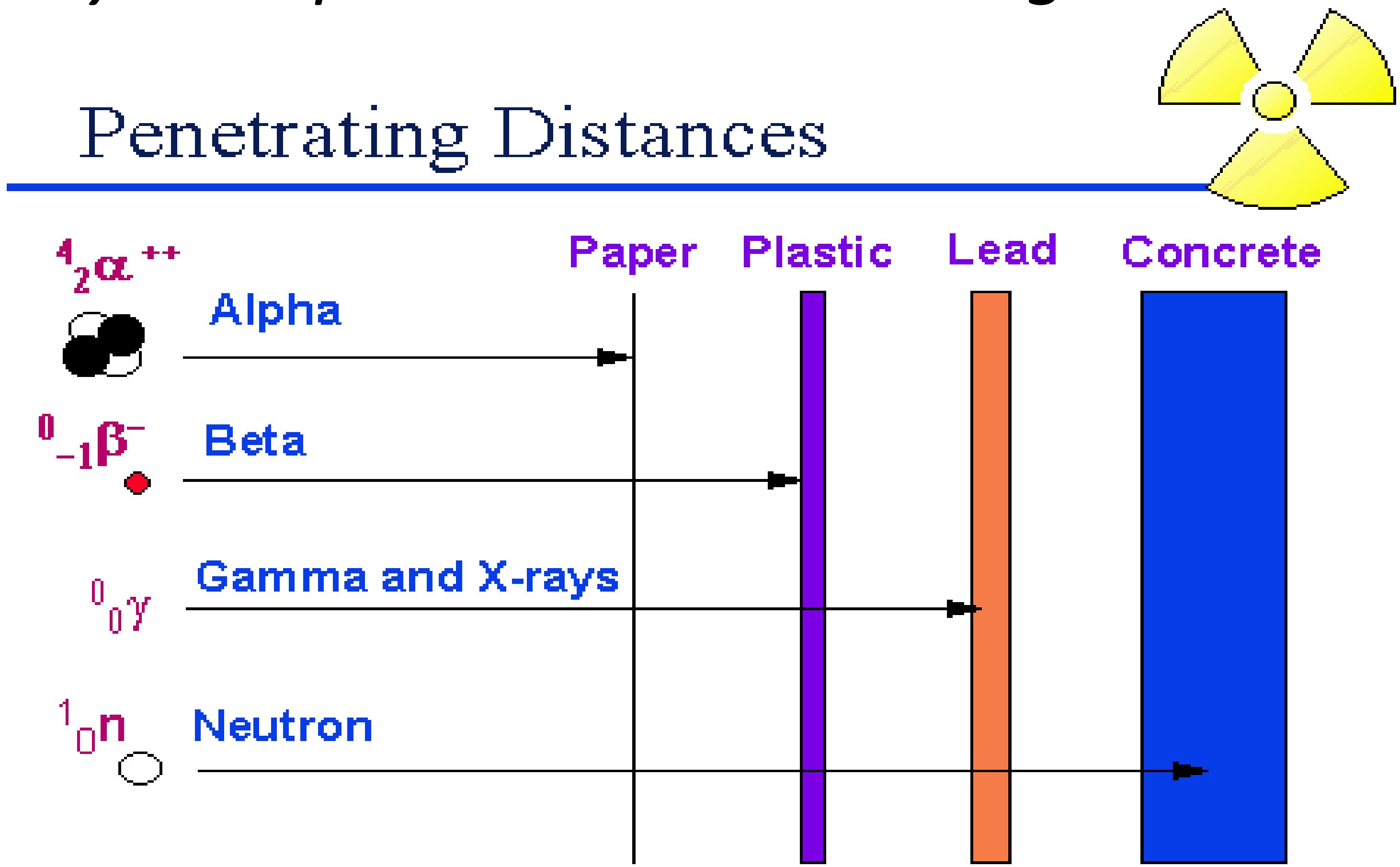
Training acknowledgement forms RSC108 and RSC108C and the completed quiz must be filed with Radiation Safety

What are X-Rays?

- X-rays are electromagnetic radiation (EM)
  - A photon of X-ray and gamma ray radiation can ionize matter
    - Other EM radiation is non-ionizing (radio, infrared, visible, ultraviolet)
- X-rays are a valuable tool in research, but there are associated health risks.
  - These risks can be minimized by adhering to the safety practices explained in this module.
- X-rays are capable of traversing great distances and have the ability to penetrate material.
  - However, they can be blocked or attenuated by shielding made from dense materials such as lead and concrete.

Radiation Shielding

x-rays compared to other ionizing radiation

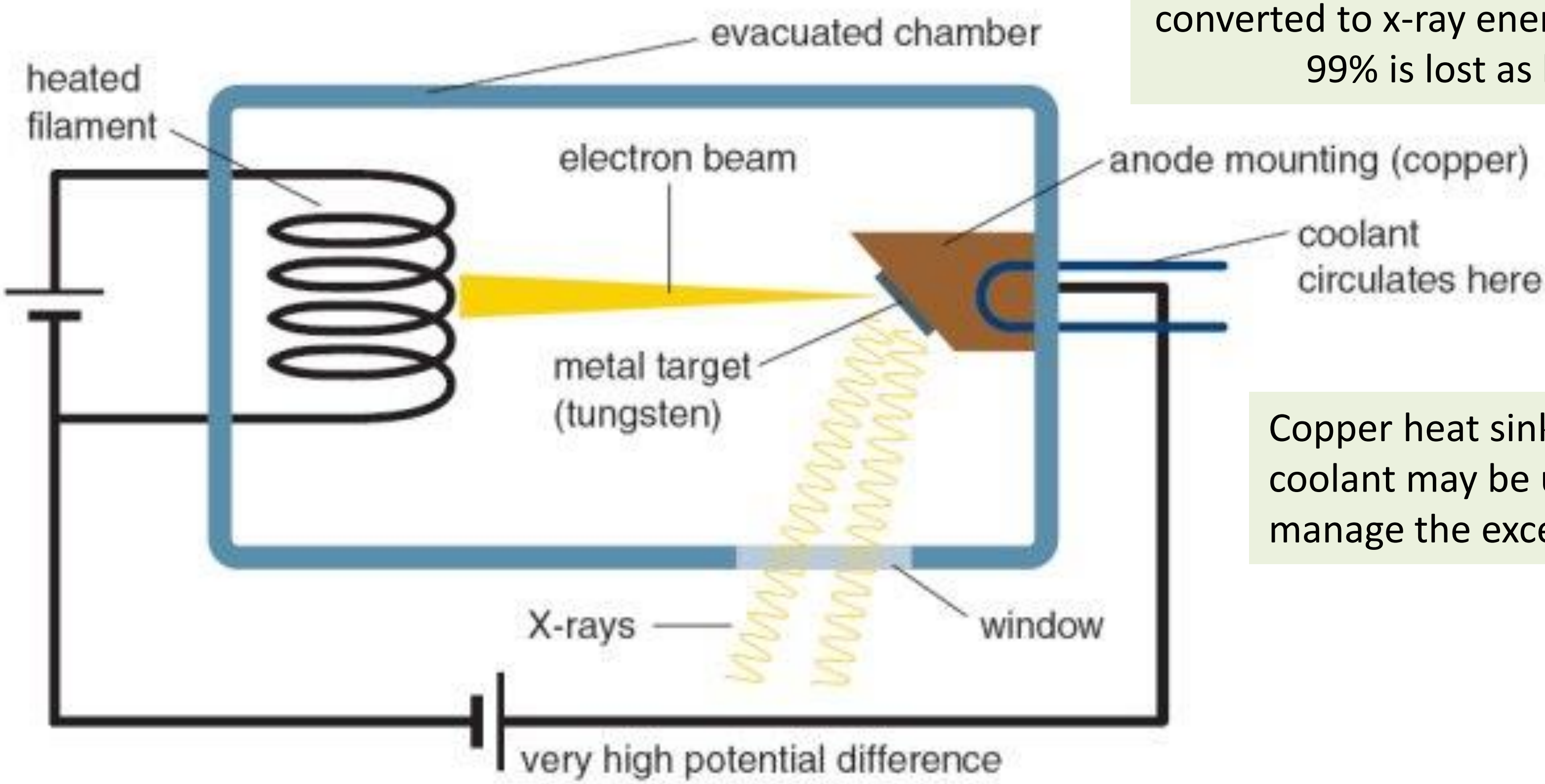


Lead has a high atomic number (called the Z#), making it a good material for shielding X-ray radiation

Components of an X-ray tube

X-rays are produced when electrons that have been accelerated using a high voltage source are abruptly decelerated by interacting with a metal target

1% of the electron's kinetic energy is converted to x-ray energy, the other 99% is lost as heat



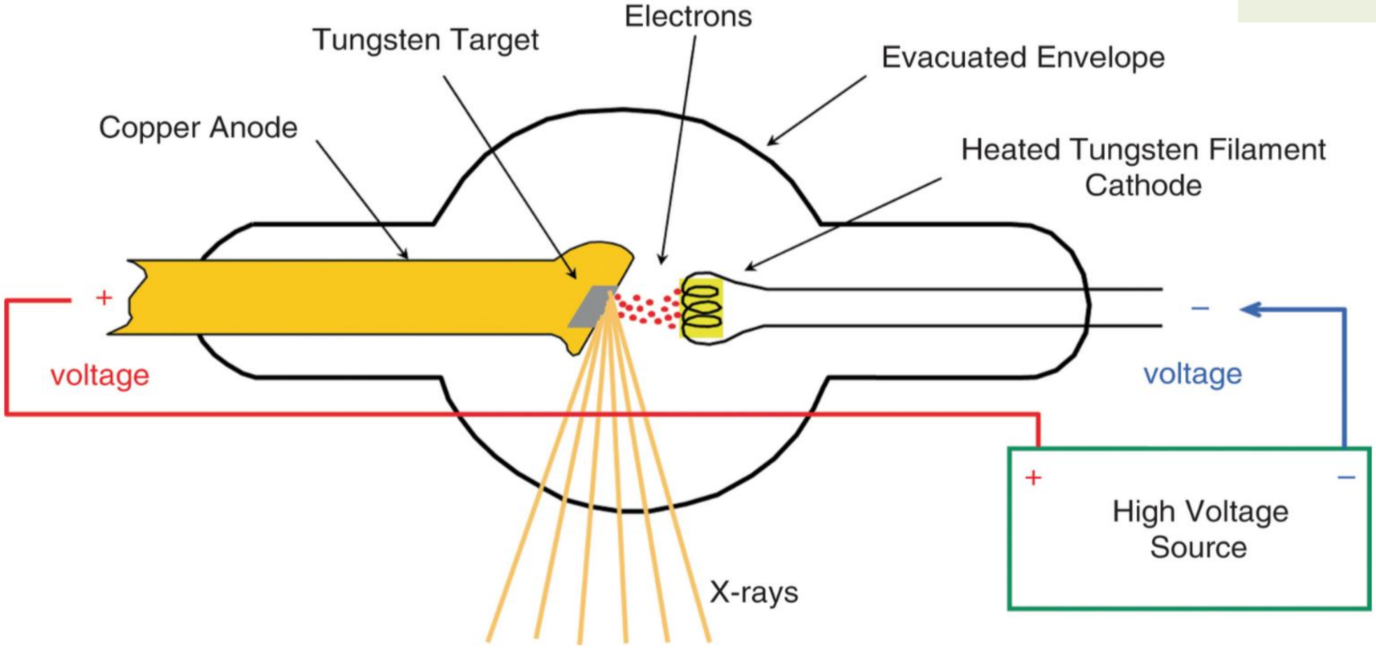
Copper heat sinks and coolant may be used to manage the excess heat

Components of an X-ray tube

The mechanisms by which the kinetic energy of the electron is converted to x-ray radiation are called Bremsstrahlung and Characteristic x-rays. These mechanisms produce a spectrum of x-ray energies. The theoretical maximum x-ray photon energy produced is equal to the voltage on the x-ray tube.

Common metals used as the target in the anode include W, Cu, Mo.

Tungsten is also used in the cathode filament.

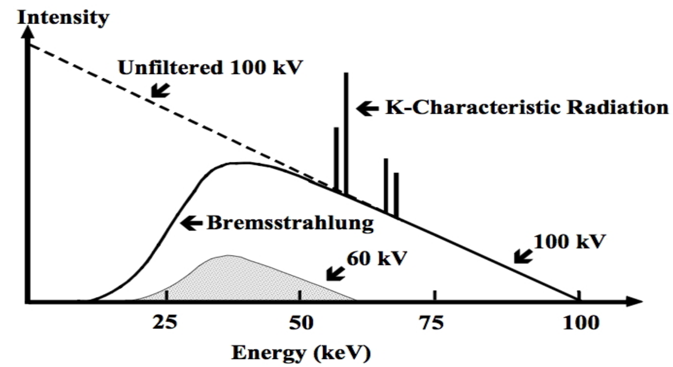


X-ray are only present when power is applied to the x-ray tube

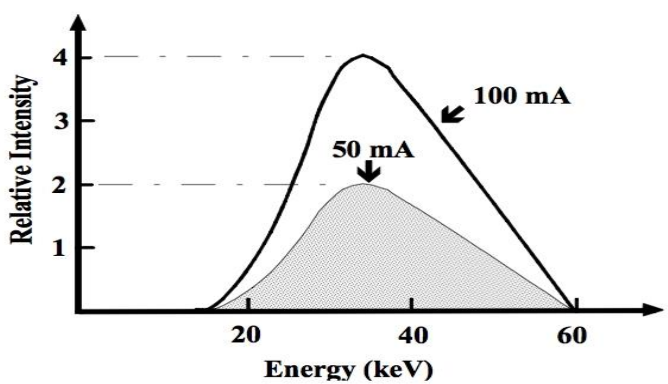
X-ray Operating Parameters kVp and mA

The energy and quantity of x-rays produced by the x-ray tube is proportional to the operating potential voltage (kVp) and current (mA).

Higher kVp → more energetic x-rays (higher keV photons)



Higher mA → more x-ray photons (quantity)

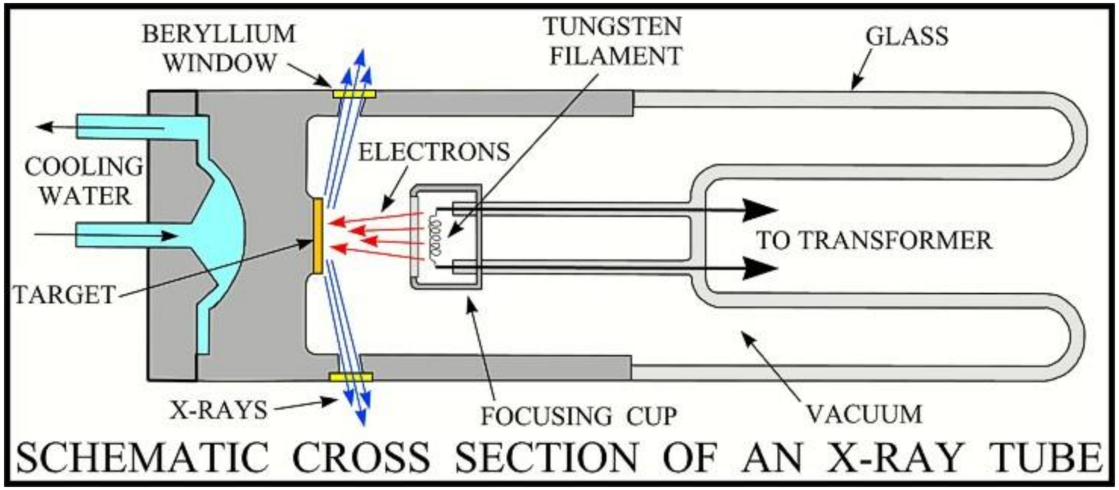


Comparing kVp and mA

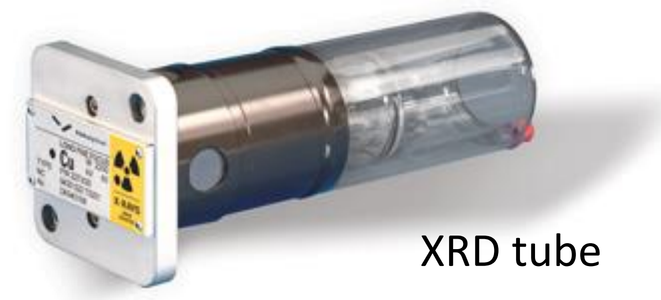
Examples of operating parameters	
X-ray Diffraction (XRD)	50 kVp / 50 mA
Handheld X-ray fluorescence (XRF)	50kVp / .01 mA

Note the much lower mA for XRF compared to XRD, though they have the same kVp. This shows that the XRF produces x-rays with similar energy as XRD, but a much lower quantity of these x-ray photons are being produced by the XRF.

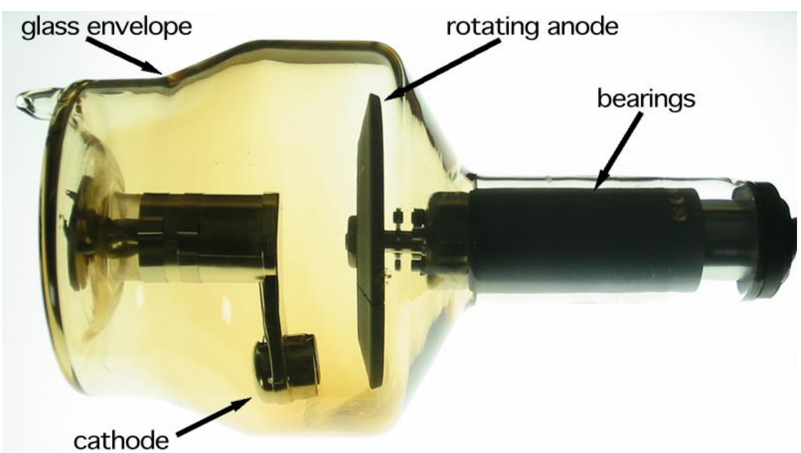
The actual voltage across the x-ray tube may fluctuate, so operating voltage is expressed in units of "kVp", the peak voltage.



An XRD tube using cooling water to remove excess heat from the anode target



XRD tube



A medical x-ray tube using a rotating anode to prolong tube life

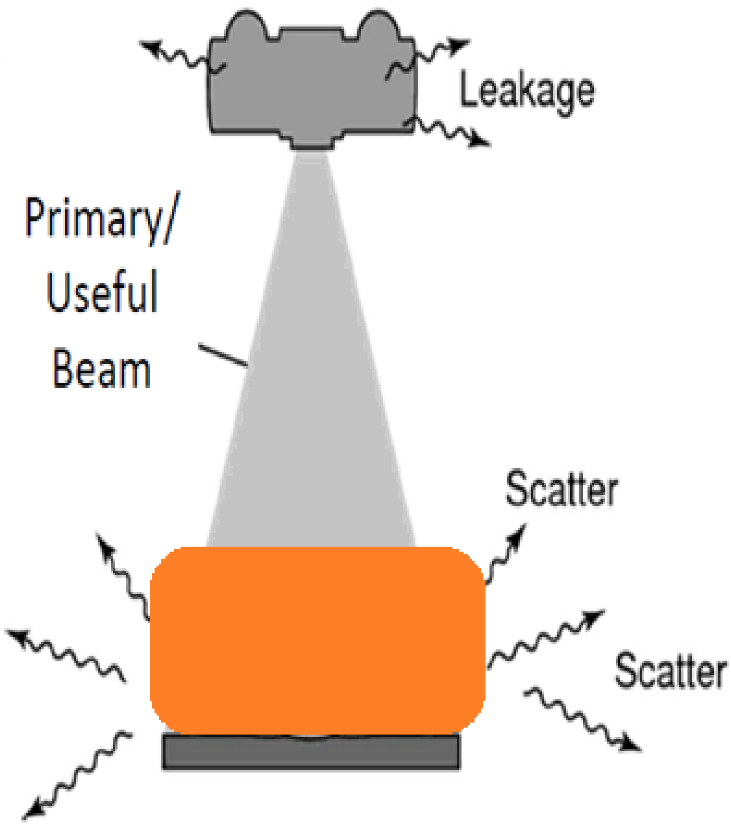
Primary Beam and Scatter Radiation

Primary Beam

- The primary beam is a significant hazard, even very short exposure times can result in severe radiation burns.

Scatter radiation

- Produced when the primary beam interacts with samples and structures in the x-ray enclosure. Scatter radiation is a hazard near the sample.
- **Leakage radiation** from the x-ray tube is very low and not a hazard when the tube housing is intact.



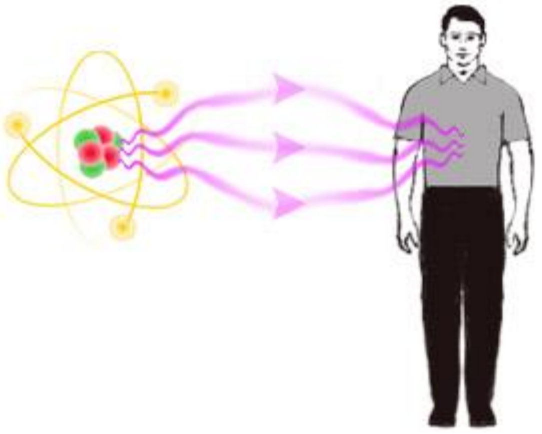
Secondary radiation levels outside the enclosure cabinet are very close to background radiation levels.

Biological Effects of Radiation Exposure

Radiation is one of the best-investigated hazardous agents. Radiation levels can be readily controlled and monitored so work may continue at a level of risk that is much less than with many other technologies.

The following slides present topics essential for working safely with radiation:

- Radiation dose units
- Acute vs. chronic radiation exposure
- Effects of radiation exposure
  - radiation burns
  - radiation sickness
  - long-term effects of exposure to radiation
- Radiation Dose Limits
- General Radiation Safety



Why are different units used to measure exposure to radiation?

Absorbed Dose

Radiation induced biological effects result when x-ray energy is absorbed by the target tissue. Therefore, biological radiation damage is approximately proportional to the ‘absorbed dose’.

- Units of absorbed dose are **rad** or Gray (**Gy**)

Effective Dose (or simply ‘dose’)

Takes into account <u>tissue sensitivity</u> to a particular type of radiation such as beta, gamma, x-ray or alpha radiation.

- This use of biological effectiveness is more useful than absorbed dose for assessing the affects from exposure to radiation
- Units of dose equivalent: **rem** or Sievert (**Sv**)
  - Often expressed in mrem (1/1000 of a rem)

Acute vs. Chronic Radiation Exposure

- **Acute exposures**
  - One-time event
  - High level doses involved (>100 rem or 1 Sv)
  - Symptoms appear quickly (within days or weeks)
- **Chronic exposures**
  - Long-term
  - Low level doses involved
  - Effects will appear slowly because the body has time to heal itself after exposure. The effects, if any, will appear 20-30 years after exposure.

Radiation Burns

- Occur as a result of an <u>acute localized exposure</u>.
- Radiation burns can occur from a wide range of exposures and <u>usually result from direct exposure to the primary beam</u>. High-energy x-rays readily penetrate the outer layer of skin that contains most of the nerve endings, so you may not feel an x-ray burn until the damage has been done. Extreme cases involve skin grafts or amputation of fingers.
- The hands, fingers and eyes are the parts of the body most commonly at risk.
- The severity of the burn will depend on the dose received, the length of the exposure, the energy of the x-rays and the sensitivity of the individual.
- Burns can be caused with exposures of 300 rem, but normally do not become apparent below exposures of at least 600 rem.

Radiation Sickness

- Occurs when a large dose is received to the whole-body.
- Symptoms usually will not start to appear unless the exposure is greater than 100 rem delivered within a few hours. Changes in blood tissue may be evident at exposures as low as 25 rem.
- If a whole-body dose of 400-500 rem is received, approximately 50% of those exposed will die within 30 days if untreated (LD50/30). Recovery is likely with medical care although the exposed individual will suffer several months of illness.
- Exposure to a dose in excess of 700 rem to the entire body in a short period of time [acute exposure] will likely result in death within a few weeks.
- If the radiation dose is spread over several weeks, a person may survive a whole-body dose as large as 1000-2000 rem.

Long-Term Effects

- Long-term effects resulting from *chronic* exposure to ionizing radiation include carcinogenesis, life span shortening, and cataract formation. The principle delayed effect from chronic exposure to radiation is an increased incidence of cancer.

- Long-term effects of an *acute* exposure to radiation are often classified as leukemia and other cancers, radiation-induced life shortening, genetic effects and embryonic effects.
  - Genetic defects are less likely than cancer, and not as serious, therefore, the risk of developing cancer from radiation exposure is more significant.
  - Radiation exposure in-utero can result in spontaneous abortions, congenital abnormalities, impairment of growth and mental functions, and increased incidences of leukemia.

Exposure/Dose Limits

- In an effort to reduce the risk of health effects caused by radiation, regulatory agencies have set exposure limits for those working with radiation and radiation producing devices.

- The limits are created such that, an individual who is exposed to the maximum allowable quantity of radiation, is well below the cut-off for the onset of serious health effects.

Oregon Department of Health sets radiation exposure limits to reduce risk to workers and the public

Exposure Limits for Radiation Workers and the Public*	
Whole Body (deep dose)	5 rem/year
Whole Body/Skin (shallow dose)	50 rem/year
Extremities (hands and feet)	50 rem/year
Eye	15 rem/year
Fetus ("Declared Pregnant Worker")	0.5 rem/gestation period
General public	0.1 rem/year

Doses at OSU are kept as far below these limits at reasonably achievable

Typical radiation exposure for XRD and cabinet x-ray operators is less than .010rem/year

**Oregon Rules for Control of Radiation OAR 333-120-0100*

Background Radiation

Background radiation is radiation that can be found all around us, in soils, in our air and water, and in our bodies. Sources of background radiation may be naturally occurring or man made

Natural sources of background radiation (average 310mrem/year)

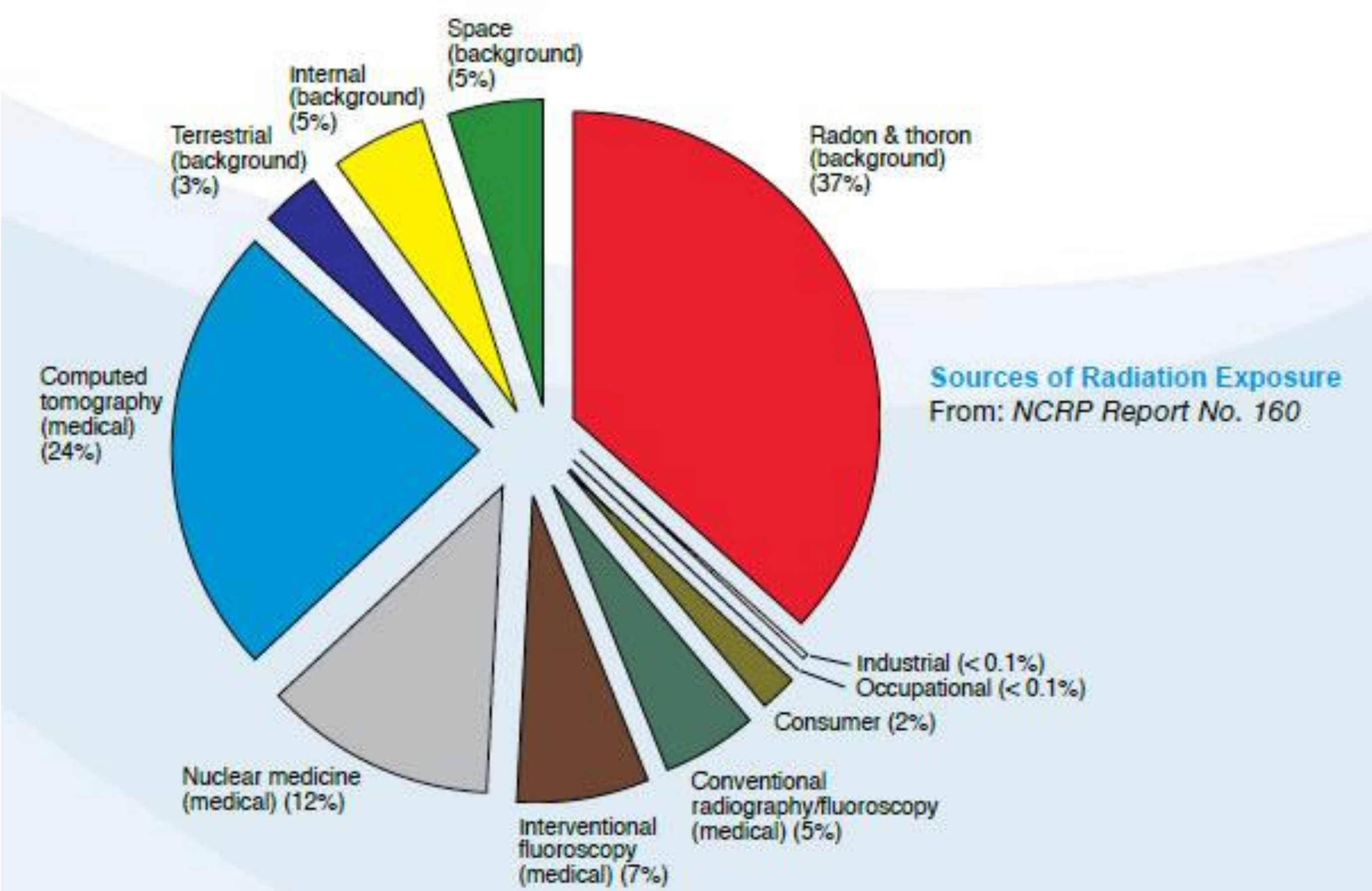
- The largest source of background radiation are radon gases from soil and rock.
- Internal exposure from naturally occurring radionuclides in the body accounts for about 5% of our background radiation exposure.
- The sun and stars send a constant stream of cosmic radiation to Earth. Differences in elevation, atmospheric conditions, and Earth's magnetic field can change the amount (dose) of cosmic radiation that we receive.

Manmade sources of background radiation (average 310 mrem/year)

- Medical uses of radiation are by far the largest component of manmade background radiation.
- Non-medical sources account for about 3% of our radiation exposure, including industrial, occupational, consumer sources.

The average dose to an individual from background radiation in the U.S. is 620mrem/year

Average U.S. Background Radiation Sources



Average annual background dose from all sources = 620mrem

In SI units this is equal to 6.2mSv

Pregnant X-ray Users

- Pregnant individuals should take all precautions possible to keep exposure to the embryo or fetus as low as possible.
- Oregon State University makes available extra precautions for a Declared Pregnant Woman.
  - ‘Declared Pregnant Woman’ means a woman who has voluntarily informed the Oregon State University Radiation Safety Officer, in writing, of her pregnancy and estimated date of conception (Declaration of Pregnancy).
  - The declaration remains in effect until the declared pregnant woman withdraws the declaration in writing or is no longer pregnant.

Pregnant X-ray Users

- The <u>dose to the fetus </u>of a declared radiation worker is limited by Oregon Rules to 0.5 rem during the gestation period
  - The regulatory dose limits to the mother do not change because of declared pregnancy status

- If a declared pregnant worker has the potential to be exposed to radiation that a badge will detect, she may be issued a fetal monitoring badge
  - The fetal monitor is a badge worn at waist level

- All personnel dosimeters, including the fetal radiation dosimeter, are provided free of charge.

Typical radiation exposure for XRD and cabinet x-ray operators is less than .010rem/year

ALARA
(As Low As Reasonably Achievable)

- The risk of adverse health effects (e.g. cancer) occurring can be decreased by decreasing your occupational radiation dose.

- The goal of ALARA is not only to remain below the exposure limit, but to keep radiation exposure As Low As Reasonably Achievable.

- ALARA is not just a good idea, it is REQUIRED by law.

- There are several practices that will help you keep your dose ALARA.

ALARA Radiation Protection Techniques

TIME Decrease the time spent in a radiation area to lower accumulated dose. Plan work efficiently to avoid spending too much time.

DISTANCE The greater distance between you and the x-ray unit, the lower the dose.

SHIELDING The greater the shielding, the lower the dose. Lead works well to attenuate x-rays.

DOSIMETRY Radiation monitors at the operator's console monitor radiation dose.

X-Ray Machine Terminology
The Primary/Useful Beam

- The Primary or Useful Beam is the beam emitted by the x-ray tube after it passes through an aperture in the source housing.
- The exposure rate from the primary beam of an analytical x-ray unit can be as intense as 400,000 R/min
  - Shielding, such as a beam-stop, will prevent the primary beam from escaping the enclosure or damaging internal components of the XRD.
- The exposure area of the primary beam can be less than 1 cm^2.
- The hands, fingers and eyes are the parts of the body most commonly at risk from primary beam exposure.

Although doses <u>outside</u> the x-ray cabinet are very low, radiation exposure <u>inside</u> an x-ray machine from the primary beam is very high and considered an immediate health risk.

X-Ray Units Types

CLOSED-BEAM

- An analytical x-ray system in which all possible x-ray paths (primary, scatter and diffracted) are completely enclosed so that no part of the human body can be exposed to the beam during normal operation. The x-ray tube is installed in an enclosure which is intended to provide radiation shielding, and prevent access to its interior during generation of x-ray radiation.
  - These units are the safest of the analytical x-ray units because they prevent exposure to the primary beam by including numerous safety interlocks.
  - The enclosure also have built-in shielding within the unit to prevent exposure to scatter radiation.

Most x-ray machines at OSU are closed-beam units.

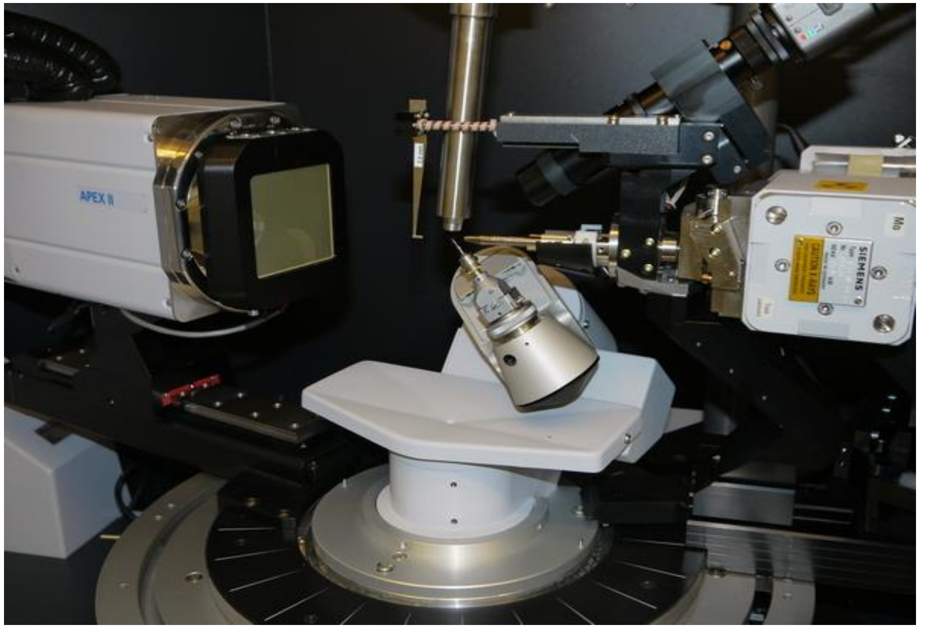
(Handheld XRF are NOT closed-beam)

X-Ray Unit Types

OPEN-BEAM

- An analytical x-ray system that is not enclosed. Therefore an individual could accidentally place a part of the body in the primary beam path during normal operation.

Open units present the greatest potential for injury because the primary beam is accessible to the user.



X-Ray Unit Types

Portable X-ray Fluorescence Analyzers (XRF)

- A handheld XRF. Operated in an open-beam configuration, but the sample must be in contact with the XRF before the XRF will irradiate the sample.

The XRF must have a built-in proximity sensor and backscatter detector. Both these safety devices are used to prevent accidently firing the x-ray without a sample placed against the beam port.

Safety Features
Machine Controls

- **Beam Shutter**: Opens or closes, allowing or preventing the primary beam to pass.
- **Beam Stop**: composed of high Z material (e.g. Pb) that will absorb the primary beam that passes through and around the sample. This device works to stop the primary beam and reduce the scatter radiation that would be caused if the primary beam were to strike components of the unit housing.
- **Fail-Safe Characteristics**: a design feature which closes the beam port shutters or turns off the x-ray generator to prevent exposure to the primary beam upon failure of the safety warning device. All safety and warning device must be failsafe.
  - "X-Ray On" light must be present and failsafe.
  - Locks to the enclosure doors must be failsafe.
- **Beam Collimation**: Focus the primary beam on the area of interest. Collimation prevents exposure to unwanted areas, reducing scatter radiation.

Safety Features

Machine Controls continued

- **Unit Enclosure**: Equipment housing designed to prevent exposure from the primary beam. These enclosures may be fitted with leaded glass windows and safety interlocks which all work to prevent the operator from being exposed to the primary beam and secondary scatter radiation.
- **Interlocks**: A series of switches and circuits that must all be connected in order for the primary beam to operate. The switches are generally connected to the warning lights, doors, beam shutter and collimator. If any of these switches are triggered and opened, the beam will shut down.
- **Standard Operating Procedures**: Step-by-step instructions necessary to accomplish the analysis. These procedures shall include sample insertion, manipulation, equipment alignment, routine maintenance by registrant, and data-recording procedures which are related to radiation safety.
  - Written operating procedures are required to be near the operating station of all x-ray machines.

Safety Features

Administrative Controls

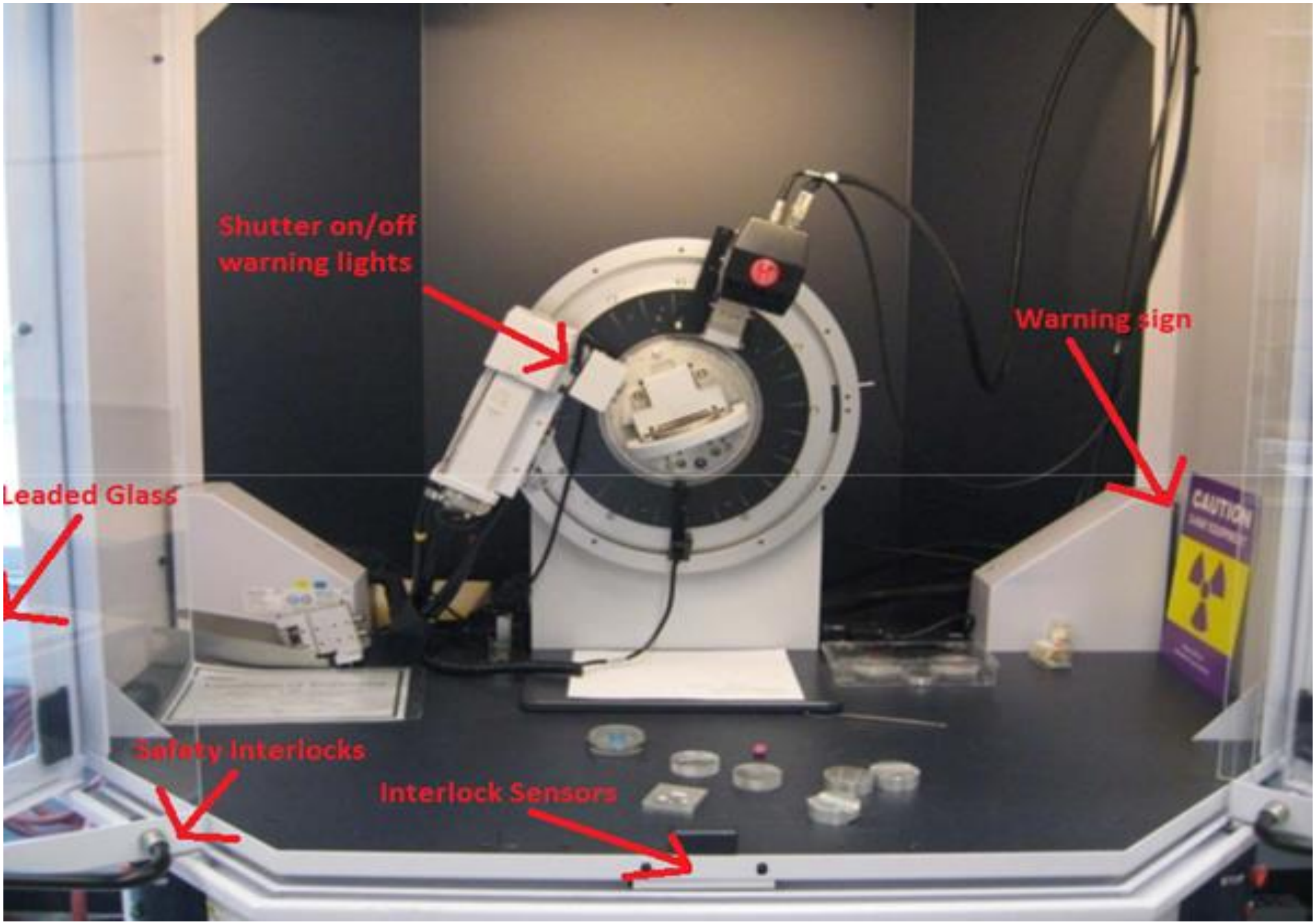
- **<u>Warning Lights</u>**: signal to the lab occupants that the x-ray beam is on or that the beam shutter is open. These are all failsafe, meaning that the beam will not energize if the lights are not operational.
- **<u>Warning Signs</u>**:
  - "Caution X-ray" at all entrances to the x-ray room.
  - "Caution Radiation: This equipment produces radiation when energized" at operator console
  - "Caution High Intensity X-Ray Beam" on source housing.

Analytical Unit Safety Features

Warning Lights

Removable Interlocked Side Panels

Analytical Unit Safety Features



X-Ray Unit Safety Features

- The safety features of x-ray units will vary depending on the type of unit being employed (i.e. cabinet, closed beam, open-beam, XRF)
- Open-beam units have the highest potential for dangerous exposures to occur because they allow the user to have access to the primary beam. Closed-beam and cabinet units are much safer to work with because they have safety features preventing the user from accessing the primary beam.
  - *Open beam XRD is rare at OSU*
- All enclosed x-ray units include the necessary safety features needed to prevent access to the primary beam and keep the potential exposures to the user at safe levels.
- Portable XRF's require adherence to special safety practices and procedures to avoid exposure to the primary beam.
- Familiarize yourself with your unit's safety features prior to use

Machine Specific Training is conducted in person with the machine administrator, and required before operating the x-ray machine

Machine Specific Training

- All operators are required to attend an orientation with the machine administrator for each x-ray machine they will use.
  - *Radiation Safety specifies a list of authorized trainers for each machine.*

- This training will familiarize you with safety features and operating procedures for each machine.

- When you have completed the training , send the Machine Specific Training Acknowledgement to Radiation Safety.

Regulations & Safety Practices

- **NEVER** bypass a safety device such as interlocks and failsafe features, shutters, etc… without approval from the Radiation Safety Officer
  - These devices are meant to protect you from serious harm and injury.
  - Notification of the RSO each time a safety device is bypassed is required by Oregon law.
- **DO NOT** operate a unit in any manner other then specified in the procedures and the conditions listed on your Radiation Use Authorization.
- **LEARN** the Standard Operating Procedures for each X-ray unit you operate.
- **DO NOT** allow anyone other than trained and certified personnel to operate the unit.
- **ALWAYS** follow the ALARA principles
  - Time, Distance, Shielding, Dosimetry

Regulations & Safety Practices

- **DO NOT** remove covers, shielding material or tube housing or perform modifications to shutters, collimators or beam stops without verifying the x-ray tube is off and will remain off until safe conditions have been restored.
  - The main switch, rather than interlocks, shall be used for routine shutdown.
- **NEVER** place any part of your body in the primary beam.
- **NEVER** use hands to hold a sample
  - (e.g. sample analysis with a handheld XRF).
- **DO NOT** attempt to operate if the X-ray unit is not mechanically intact and sound.
- **ALWAYS** control access to radiation producing equipment during use to avoid unintentional exposures.
- **ALWAYS** know the location and presence of the primary and diffracted/scattered x-ray beams

Regulations

- Due to the potential risks in the operation of x-ray machines, there are regulations that must be met. These regulations are meant to minimize the possibility and severity of exposure from these units.
- Regulatory authority and requirements exists at 4 levels
  - Federal (US Code of Federal Regulations)
  - State (Oregon Administrative Rules)
  - University (OSU Radiation Safety Manual, OSU Radiation Safety Committee)
  - Individual lab requirements (Radiation Use Authorization)

Regulations

Federal Regulations

- 21 CFR 1020.4 - Performance standards for x-ray tubes
- 10 CFR 20- Radiation protection standards
- ANSI- safety standards for x-ray devices

State of Oregon Regulations

- Radiation Protection Services of the Oregon Health Authority
  - <u>Regulates and registers each x-ray machine in Oregon</u>
- Oregon Administrative Rules (OARs)
  - OAR 333-108 “Requirements for Analytical X-Ray Equipment” (XRD and XRF)
  - OAR 333-122 “Requirements for Industrial X-Ray Machine Operations” (cabinet such as Faxitron, uCT, tomography)
  - OAR 333-120 “Standards for Protection Against Radiation”

OSU Regulations

- OSU Radiation Safety Manual
  - RSM Section 7 “Regulations Concerning Radiation Machines”
    - oregonstate.edu/ehs/rso

- OSU Radiation Safety Committee
  - Responsible for maintaining a radiation safety program at OSU
    - Bylaws in the RSM

Radiation Use Authorization
lab specific regulations

- Issued to a PI by the Radiation Safety Committee
  - May include a Lab Contact as machine administrator
- Lists authorized trainers
  - Authorized to give Machine Specific Training
- Conditions for operation
  - Authorized machines
  - Max kVp and mA
  - other conditions
- Posted in the lab

XRF Specific Practices

- Handheld XRFs deserve extra considerations due to the lack of safety features such as unit enclosures, beam shutters, beam stops and interlocks. The absence of these features allows the potential for individuals to become exposed to the primary beam and scattered radiation.

- **DO NOT** change/manipulate samples while the X-ray unit is energized.

- **NEVER** point an XRF at an individual.

- **ALWAYS** enable safety interlocks
  - Backscatter (low count) detector
  - Proximity detector

- **KNOW** the Specific Provisions for XRF
  - Listed on the Radiation Use Authorization
- **KNOW** the manufacturer’s safety procedures.

XRF Specific Safety Practices

- BE AWARE of the primary beam's direction. The primary beam of some XRFs are emitted at an angle.
- AVOID placing any part of your body (especially eyes or hands) near the examination area during measurement. If the sample is located on a table or bench top, make sure no feet or other body parts are beneath.
- If the primary beam is directed toward a wall or floor, make sure the other side of the barrier is unoccupied.

Monitoring X-Ray Machine Exposure

- Exposure rates within the area will be determined when the unit is first installed. The initial inspection will ensure that there are no exposures in the area that would result in harm to users.

- Annual inspections will be performed by qualified Radiation Safety Office staff to ensure that the exposure rates are within acceptable standards, and safety devices are intact.

- Inspection of the unit should be requested by the lab staff if any of the following occur:
  - The unit is moved
  - The unit is altered in any way that may affect the interlocked safety features
  - Operating procedures are significantly altered such that the radiation profile inside the enclosure is significantly changed

Monitoring Radiation Exposure

- Radiation dosimeters are placed at the operator's console to record radiation levels outside the x-ray machine

  - Sensitive to 10mrem (0.010rem)
  - Exchanged quarterly
  - Generally, these dosimeters record no radiation above natural background; positive readings are very close to background levels

- Radiation survey meters
  - Geiger-Mueller(GM) or Ion Chambers can be used to detect x-ray radiation. Either can be used to take measurements on an x-ray machine. Ion chambers are better at making quantitative x-ray measurements than GM meters.
  - X-ray machine labs are not required to have radiation meters available. Radiation Safety has meters that can be loaned to the lab

Enforcement

Failure to comply with the rules and regulations set by Oregon Dept. of Health, the Oregon State University Radiation Safety Manual, and the Radiation Use Authorization for the lab can result in:

- Re-training requirements.
- Loss of work privileges with x-ray producing devices.
- Civil and criminal penalties for willful violation of, attempted violation of, or conspiracy to violate any regulations.

The Radiation Safety Officer (RSO) is empowered by the RSC to immediately terminate the operation of analytical x-ray equipment found to be a threat to health, safety, or property until the violation is corrected.

Security

- Only individuals that are listed as authorized users on the specific x-ray machine may have the ability to operate the x-ray unit(s)
- Notify Radiation Safety and the supervisor/PI if an unauthorized user is found using an x-ray unit.

Reminder - Training Requirements for X-Ray

- **X-ray awareness training (this training).**
- **Quiz**
- **Machine specific training for each x-ray unit.**
- ***Must be documented with Radiation Safety.***

X-ray machine acquisition

- Radiation Safety must be notified <u>before</u> the purchase of an x-ray machine.
- A Radiation Use Authorization (RUA) issued by the OSU Radiation Safety Committee is required for possession and use of any x-ray machine.

Required Postings

Notice to Employees

State of Oregon notice to radiation workers

Machine Registration Certificate

State of Oregon registration for each machine

Radiation Use Authorization

Issued by the Radiation Safety Committee to the PI, authorizing use of the x-ray machine

Lab Hazard Sign

Posted at each entrance to the lab

Required postings are provided and installed by Radiation Safety

Radiation Safety Responsibilities

OSU Radiation Safety is responsible for

- Performing a radiation survey and compliance inspection when x-ray equipment is first installed, and when equipment is relocated or reconfigured in any way that affects radiation safety;
- Performing an annual survey and inspection of each x-ray machine;
- Providing x-ray safety training for x-ray users;
- Providing radiation monitoring badges where required or requested;
- Complying with regulations set forth by the Oregon State Department of Human Services, for the safe use of radiation producing devices such as x-ray units
- Registering all x-ray machines with the State of Oregon.

Program Director/PI Responsibilities

- Obtaining a Radiation Use Authorization
- Verify required postings
- Verify training for all users
- Prevent unauthorized use of the equipment
- Maintain a usage log for each machine
- Provide standard operating procedures
  - Kept at machine console
- Notify Radiation Safety before moving or disposing of an x-ray machine
- <u>The Program Director is responsible for the safe and proper use of x-ray machines</u>

Usage Log

A usage log must be maintained for each x-ray producing machine. An entry shall be recorded on the usage log for each time the equipment is utilized. A period of use is defined as a consecutive period of time when x-rays are being generated. At a minimum, the following information shall be recorded for each period of use:

- Operator Name
- Date
- Start Time
- End Time
- X-Ray Unit Make, Model, and Serial Number
- Equipment Supervisor
- Operating Parameters (voltage and current)

Questions?

When you have any questions, contact your machine administrator.

Or, contact Radiation Safety directly at

- Radiation Safety Office
  - phone 541-737-2227
  - fax 541-737-9090
  - email **radiation.safety@oregonstate.edu**
- Mailing Address:
  OSU Radiation Safety Department
  100 Oak Creek Building
  3015 SW Western Blvd
  Corvallis, OR 97331-7405

- Web: oregonstate.edu/ehs/rso

Completion and Exam

- This concludes the PowerPoint portion of the training.
- Complete the test at the link below. A minimum score of 75% is required to pass. Your quiz results will be emailed to you.
- Submit a completed RSC108 (Acknowledgement and Prior Dose Form) signed by you and your Principal Investigator) and send it through campus mail to Radiation Safety, OCB. Or scan and email the form to radiation.safety@oregonstate.edu.

Click here to take the exam.
ONID authentication is required.