LA-UR-24-22818

Approved for public release; distribution is unlimited.

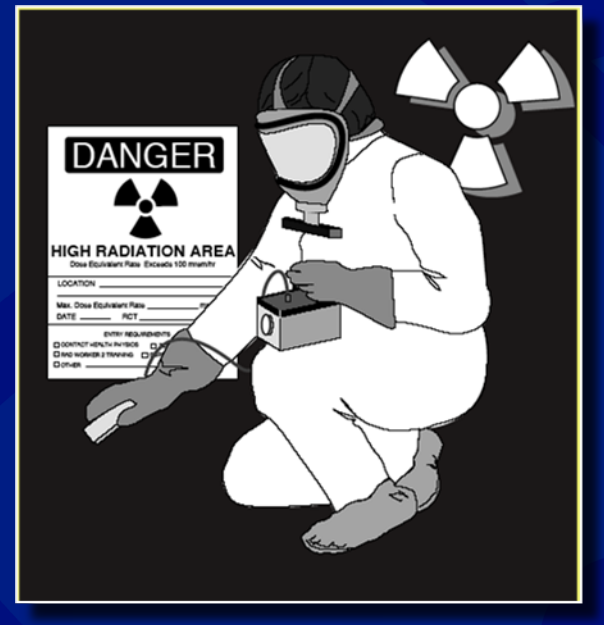
Title:	Radiological Worker II Training Course #20301
Author(s):	Sturm, Andrew Thomas
Intended for:	Report
Issued:	2024-03-28

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by Triad National Security, LLC for the National Nuclear Security Administration of U.S. Department of Energy under contract 89233218CNA000001. By approving this article, the publisher recognizes that the U.S. Government retains nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

Los Alamos
NATIONAL LABORATORY

Radiological Worker II Training
Course #20301



RP-Programs

February 2024

Exams

12909- Initial Written Exam/ 49525 Refresher Exam
57810 – Schedule your practical evaluation
12910-Practical evaluation graded item

LA-UR

Class Agenda (approximate times)

- **Today**
  - 8:00 to noonish Classroom presentation
  - 1:00 to 4:00 Donning and Doffing of PPE review and Independent Study of Course Manual

- **Second Day**
  - Email esh-registration@lanl.gov to reserve your exam seat for test #12909, if you are NOT placed in an AM or PM group for tomorrow. If you are taking the 24-month refresher, you can now take it on Utrain exam #49525.

  - For the Rad practical exam #12910, students will book their appointment in Utrain using non-train test item #57810

Overview

Radiological worker training is the basic building block for any additional radiological training you may receive. Upon completing radiological worker training, you will have the basic knowledge needed to work safely, using proper radiological practices, in areas where radiological hazards exist. You will also have a better understanding of the hazards and responsibilities associated with radiological work, to help prevent the carelessness that can occur when working continually with or around radioactive material.

This course does not qualify you for any specific radiological work. You may be required to take additional training at individual facilities to address facility and job specific hazards and procedures.

Radiological Worker Test

- The *Radiological Worker Test* is a 50-question, multiple-choice, **open-book** test that must be retaken every 24 months.

- The *Radiological Worker Practical* needs to be taken only once for LANL work.
  - Note: Radiological work at other DOE sites, such as the Nevada National Security Site, requires that the practical be retaken every 2 years.

- The passing score for each is 80%.

You are required to pass an electronic exam #12909 with this class.

If you have a **PIV** or **CRYPTOCard** with administrative (A-level) access, you **MUST** have it with you to be proctored for the test.

Radworker Training Compliance Documents

- 10 CFR 835: Prescribes radiation safety training
- DOE Handbook 1130-2022: Specifies radiological worker training objectives and course content
- P121-1.0: Provides LANL occupational radiation protection requirements
- At LANL, “radiological worker” means “Radiological Worker I/II”

LANL and Safe Conduct of Research (SCoR)

The Safe Conduct of Research (SCoR) is a set of eight principles and practices that ensure our science and operations are performed without unnecessary risk and are sustained without operational disruption. The principles provide a framework for approaching our daily activities in a safe, secure and compliant manner.

The **SCoR in Action (SiA) Program** is a coordinated and managed program that tracks, supports, and shares on-going and planned SCoR-related initiatives at the Laboratory from development through integration.

Safe Conduct of Research (SCoR) Principles

The SCoR Principles are fully embraced by LANL to ensure the continued successful accomplishment of our national security mission. Despite its name, SCoR does not pertain only to safety or the employees conducting research. **The principles are specifically designed, applicable and adaptable to *all* activities and *all* workers at the Laboratory to help us conduct work more effectively.**

1. Everyone is personally responsible for ensuring safe operations. Use your safety professionals to support you. Know the hazards or ask questions until you do. Freeze work when there is uncertainty about the safe conduct of work. Follow safety requirements and processes.
2. Leaders value the safety legacy they create in their discipline. Exhibit behaviors that set the standard for safety. Coach, mentor, and reinforce expectations about safety. Be conscious of the complexity of the research, the preparedness of your staff, and the pressure to perform.
3. Staff raise safety concerns because trust permeates the organization. Raise concerns, report problems. Respectfully challenge unsafe behavior regardless of your position in the organization. Accept challenges to unsafe behavior graciously as an opportunity to improve. Create an environment of inquisitiveness.
4. Cutting-edge science requires cutting-edge safety. Take conservative measures when the impact of hazards is uncertain.

Safe Conduct of Research (SCoR) Principles con.

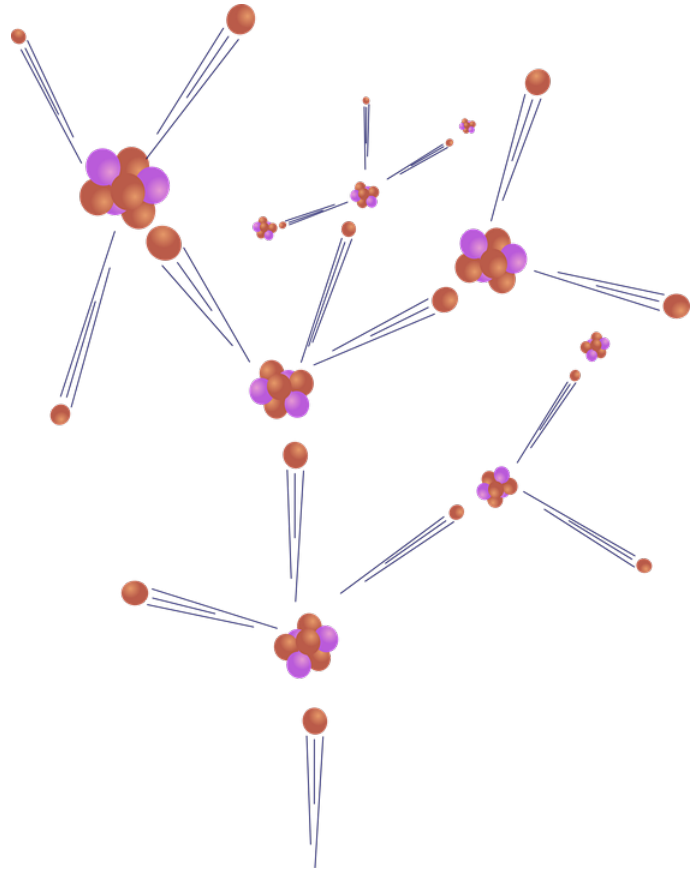
5. A questioning attitude is cultivated. Evaluate potential impacts and put controls in place to mitigate them before you begin work. Investigate and mitigate anomalies. Encourage opposing views to advance everyone's understanding. Don't let debate paralyze sound decision making.
6. Learning never stops. Make safety techniques and lessons learned part of routine topics in research discussions. Look for opportunities to improve safety with every experiment, event, or project. Treat mistakes and challenges from others as opportunities to learn.
7. Hazards are identified and evaluated for every task, every time. Understand the hazards associated with your work, the controls necessary to do the work safely, and the rationale behind the controls selected. Constantly reevaluate procedures and safety components to ensure they still provide the protection assumed. Avoid unnecessarily taking on risk with "work-around." Involve peers to avoid blind spots to new risks.
8. A healthy respect is maintained for what can go wrong. Be aware that routine tasks can result in serious injuries or operational upsets. Acknowledge time pressure and heighten attention to safety during those times. View small failures and mistakes as clues to more-consequential failures—and share them. Use external reviews and management engagement as opportunities to challenge assumptions and reinforce what is right. Discuss contingencies before conducting first-time operations.

More information about SCoR and additional training can be found at

https://int.lanl.gov/org/ddops/aldeshq/integration-offices/scor-in-action/index.shtml

Let’s get started!

Unit 1:
Radiological Fundamentals



Objectives Unit 1

- EO 1.1. Describe the components of atoms
- EO 1.2. Describe the concept of nuclear instability
- EO 1.3. Define basic radiological terms
- EO 1.4. Identify the units used to measure radioactivity and contamination
- EO 1.5. Explain the difference between radiation and contamination
- EO 1.6. Convert various radiation measurements
- EO 1.7. Explain ionizing and non-ionizing radiation and their effects
- EO 1.8. Explain background radiation and its effects

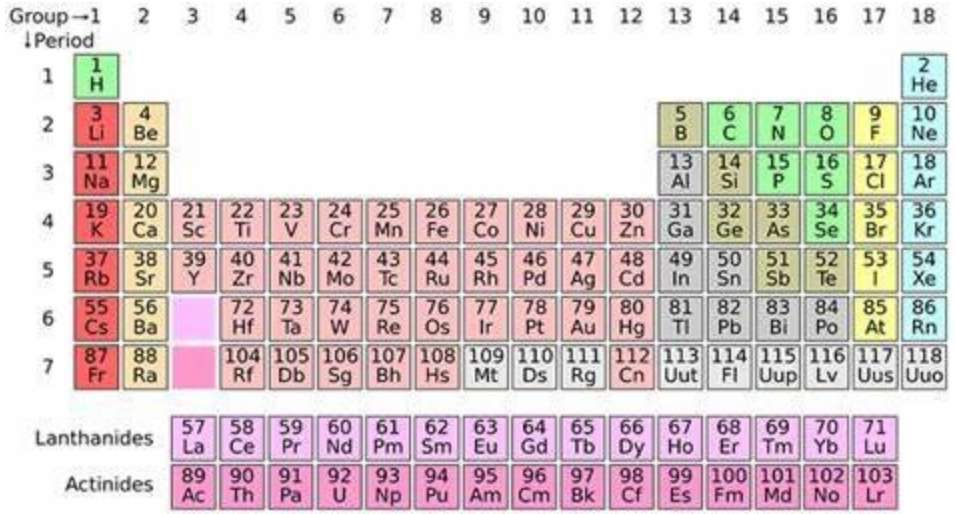
Atomic Structure

The Atom

The basic unit of matter is the atom. Atoms contain three basic particles, protons, neutrons, and electrons. At the center of an atom is the nucleus which contains the protons and neutrons while electrons orbit the nucleus.

Elements

- An element is a specific type of atom that is distinguished by the number of protons it has (atomic number) .
- Examples: Hydrogen, Sodium, Uranium



Atomic Structure

The Atomic Particles

Protons

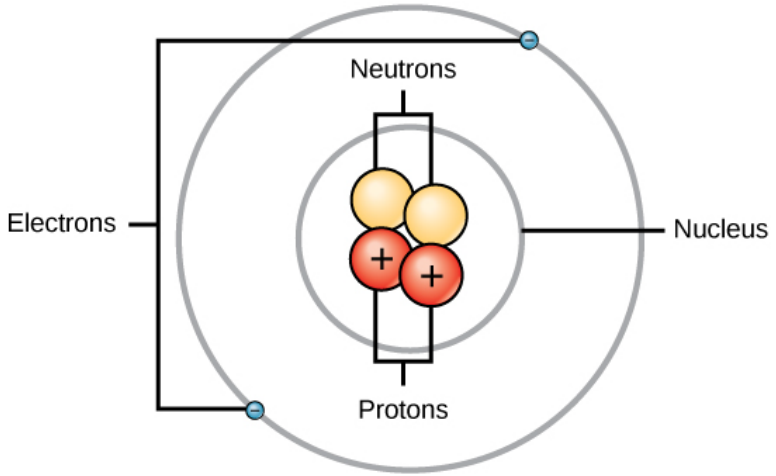
- Protons are located in the nucleus of the atom.
- Protons have a positive (+) electrical charge.
- The number of protons in the nucleus determines the element.

Neutrons

- Neutrons are in the nucleus of the atom.
- Neutrons have no electrical charge, they are neutral
- Atoms which have the same number of protons, but different numbers of neutrons are called isotopes.

Electrons

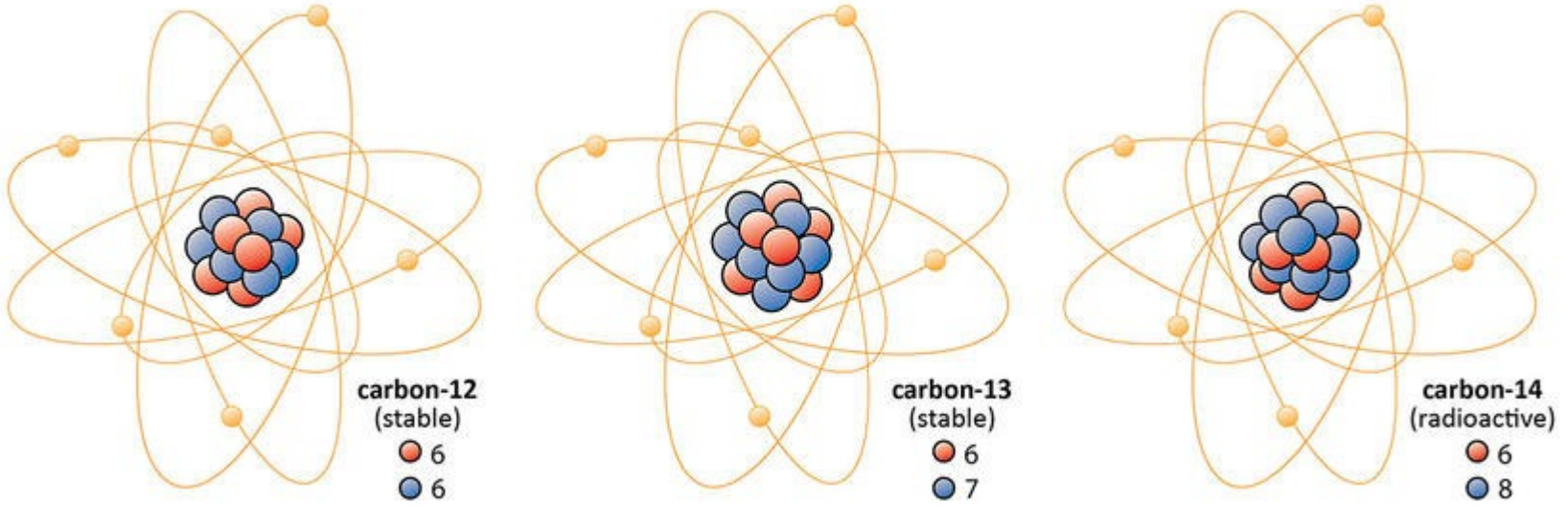
- Electrons are in orbit around the nucleus of an atom
- Electrons have a negative (-) electrical charge.
- The negative charge of the electron is equal in magnitude to the proton's positive charge.



Stable and Unstable Atoms

The balance of Protons and Neutrons in an atom is crucial for stability. If there are more(or less) neutrons than protons, the nucleus may become unstable. The atom will try to become stable by giving off excess energy as particles or rays (radiation). For example, Carbon-12 (C-12) with 6 protons and 6 neutrons compared to Carbon-14 which contains 6 protons and 8 neutrons. The extra two neutrons cause instability, and we define Carbon-14 as radioactive.

Elements can be made unstable through activation by adding/removing neutrons to an element.



EO 1.2

What is an Isotope?

Example: Uranium Isotopes

Isotopes

- Are atoms of the same element
- They have the same number of protons (+1 charge)
- They have a different number of neutrons (no charge)

92 Protons
146 Neutrons
U-238

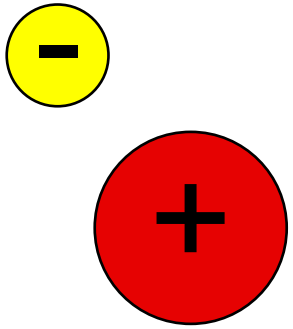
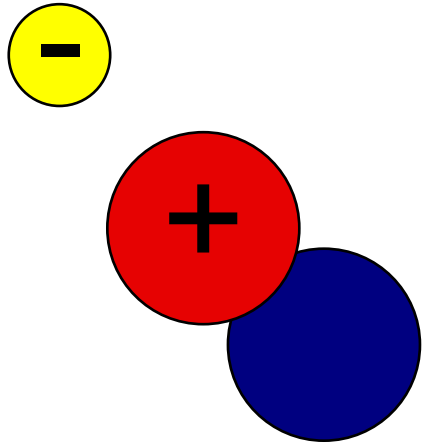
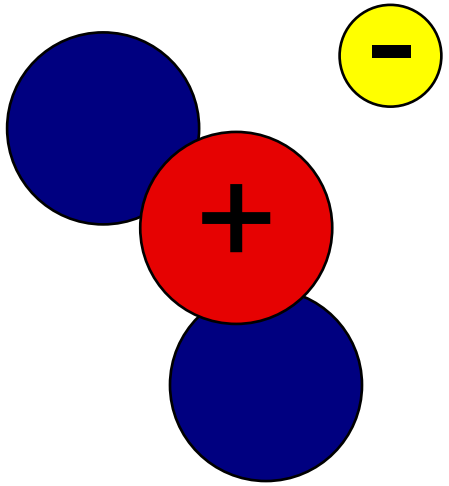
Radioactive isotopes are also called:

- Radioisotopes
- Radionuclides
- Radioactive nuclides
- Radioactive atoms

92 Protons
142 Neutrons
U-234

92 Protons
143 Neutrons
U-235

What is an Isotope?

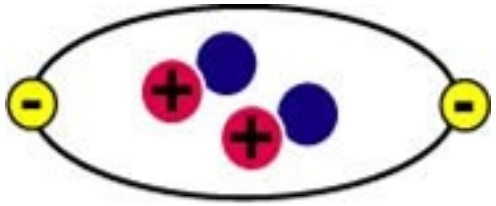
STABLE	STABLE	UNSTABLE
Hydrogen	Deuterium	Tritium
		
1 proton 1 electron 0 neutrons	1 proton 1 electron 1 neutron	1 proton 1 electron 2 neutrons

Radioactive

EO 1.3

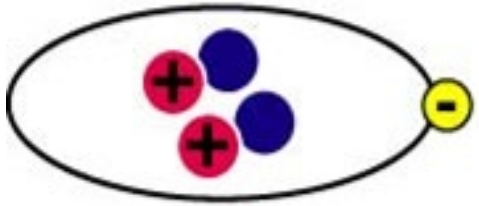
What is an Ion?

ION 



No charge (neutral)
Equal number of protons
and electrons

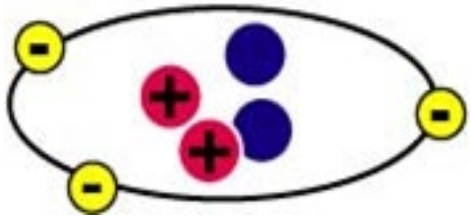
ION 



Positive charge (+)
A positive ion or charged particle
More protons than electrons

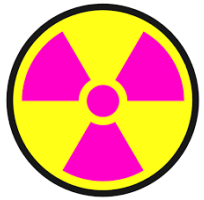
Ions are more chemically reactive than neutral atoms.

ION 



Negative charge (-)
A negative ion
More electrons than protons

Radiological Terms



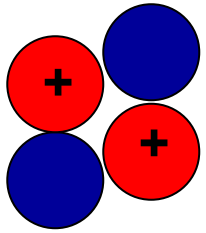
- **Radiation-** The particle(s) and/or energy released by an atom as it becomes stable.
- **Radioactivity-** The process of unstable (radioactive) atoms becoming stable. The atom emits radiation to do this. The process over time is referred to as radioactive decay.
- **Radioactive material-** Any material containing unstable atoms that emit radiation.
- **Radioactive contamination-** Radioactive material that is uncontained and in an unwanted place.
- **Radioactive half-life-** The time it takes for half of an existing radioactive atom to undergo decay. We call the new products created in the process daughter products.

EO 1.3

What is Radiation?

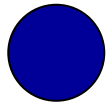
The particles or energy released from an unstable (radioactive) nucleus

- Three types of speeding particles



Alpha

Beta (- or +)



Neutron

- Two forms of energy (also called photons) waves

γ

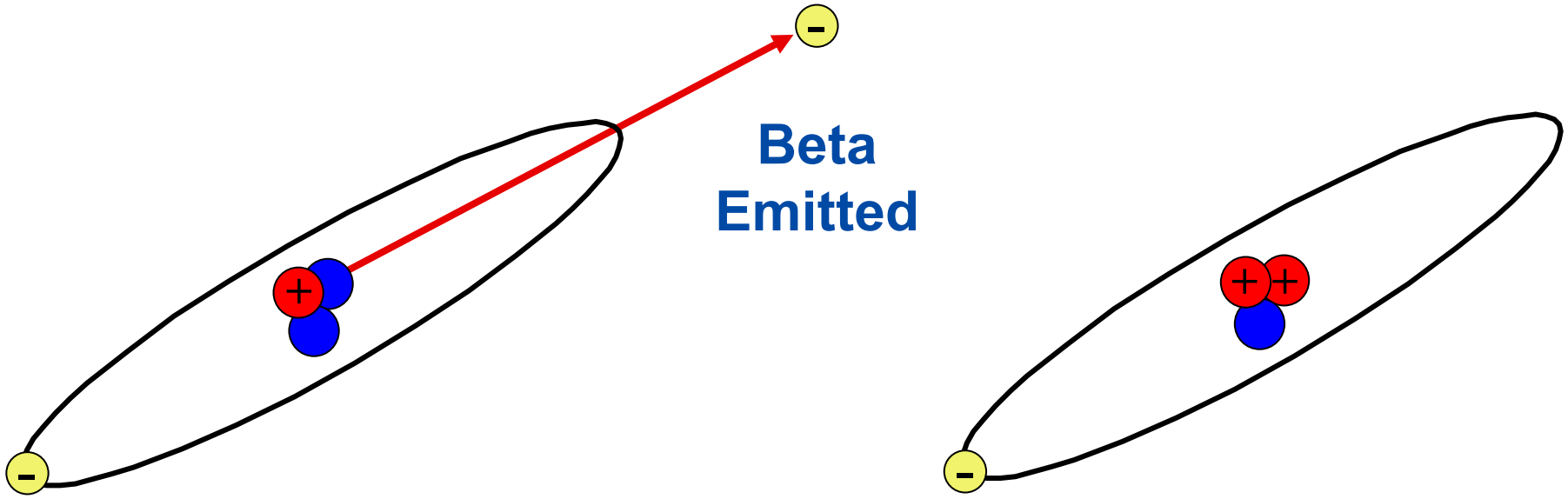
Gamma Ray

X-Ray

EO 1.3,1.5

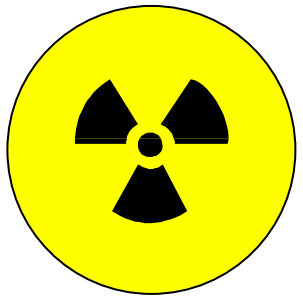
What is Radioactivity?

The spontaneous decay or disintegration of radioactive atoms

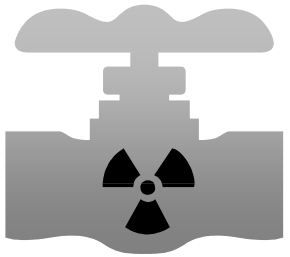


What Is Radioactive Material?

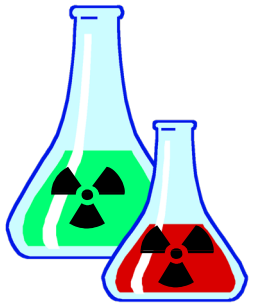
Any material containing radioactive atoms that spontaneously emit ionizing radiation.



Sealed radioactive sources



Activated components

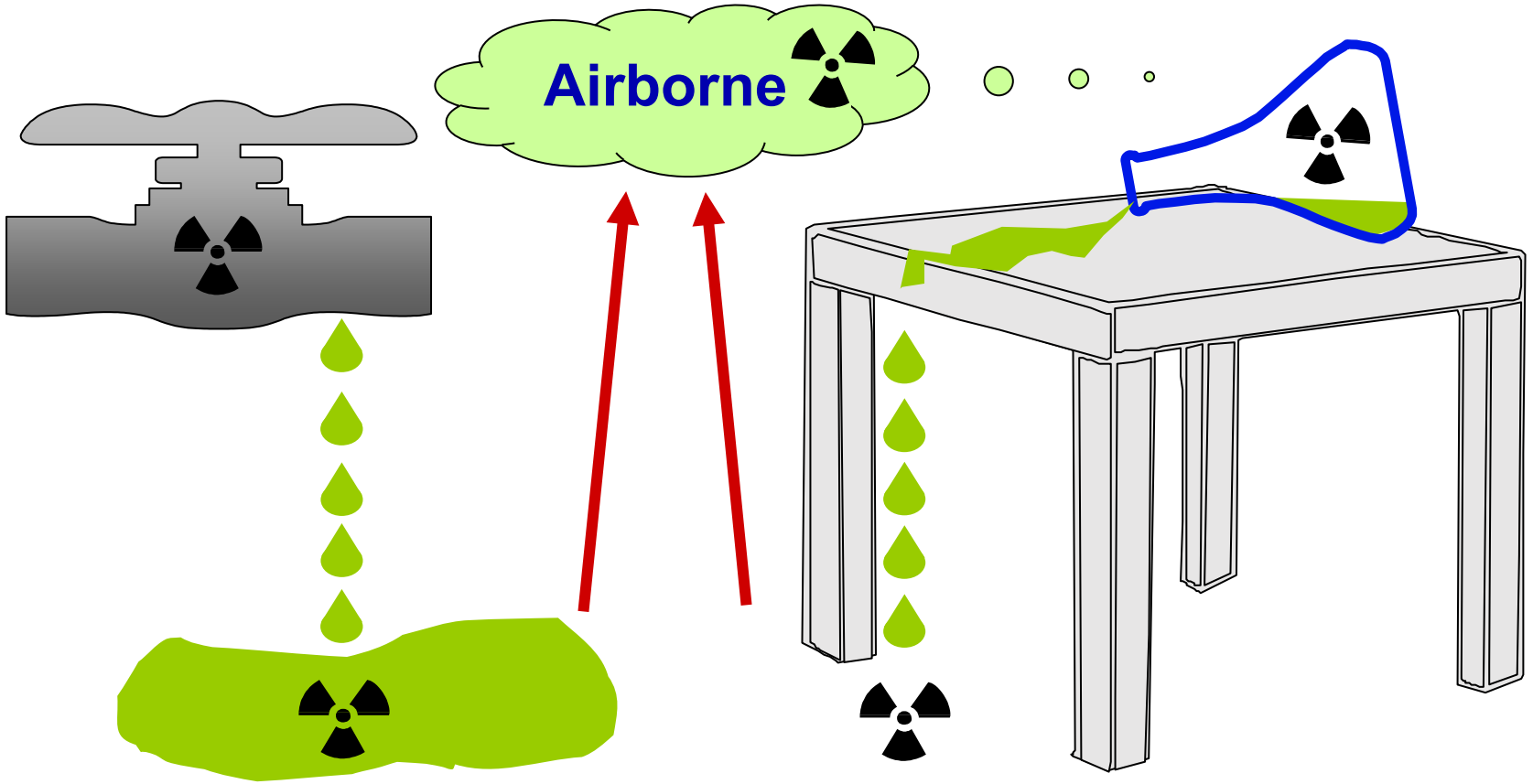


Contained for analysis or experiments

EO 1.3

What Is Radioactive Contamination?

Radioactive material in an unwanted place



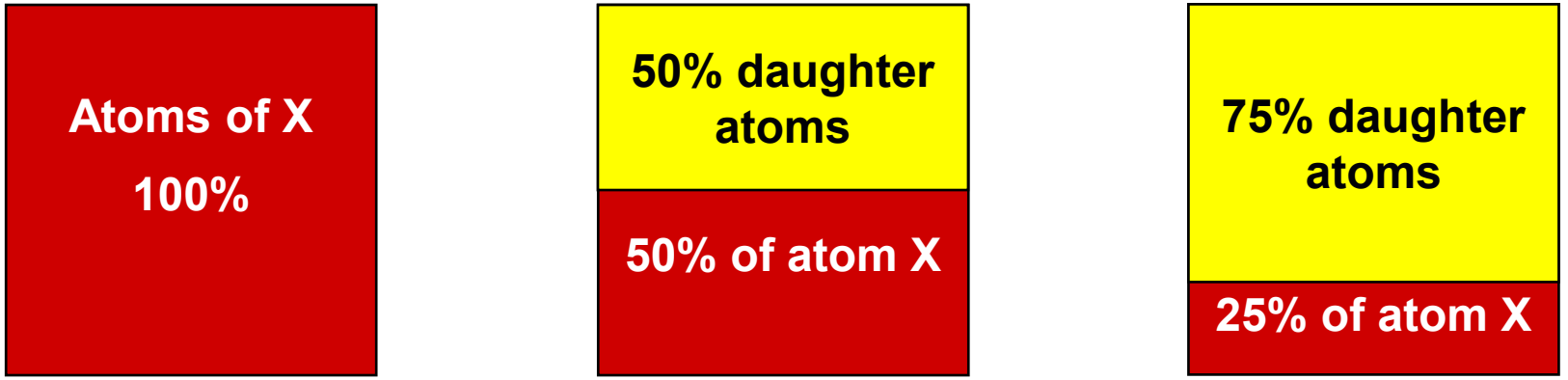
EO 1.3,1.5

What Is Radioactive Half-Life?

What does half-life mean?

The time it takes for one-half of the unstable (or radioactive) atoms present to decay or disintegrate.

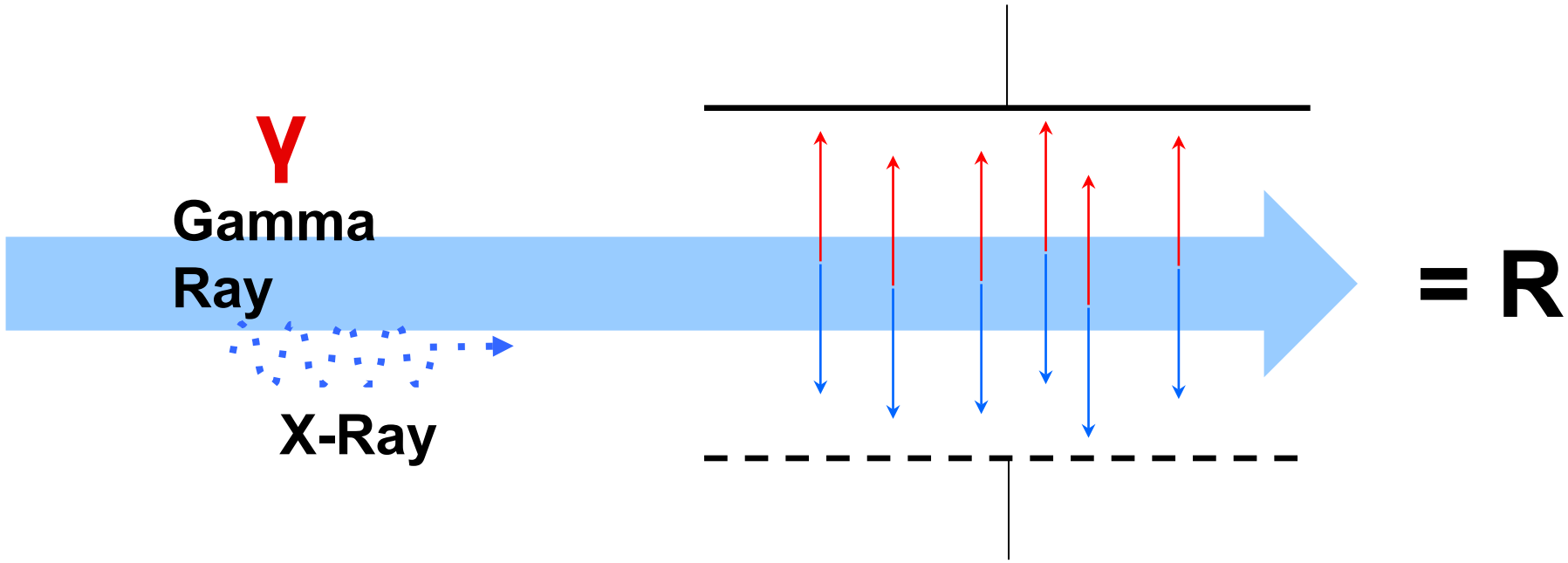
Example: Element X has a half-life of 24 days. Every 24 days half of the element x will decay into a daughter product.



Units of Measure for Radiation

roentgen (R)

- unit of exposure for ionizing radiation
- used to measure ionization in air caused by x-rays and gamma rays

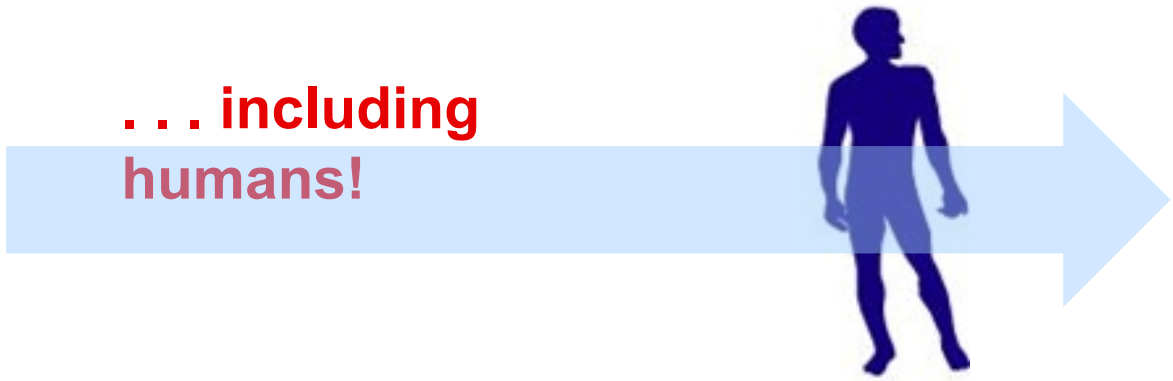


Units of Measure for Radiation

radiation absorbed dose (rad)

- a special unit of absorbed dose
- a measure of energy deposited by any type of ionizing radiation into any type of material

. . . including humans!



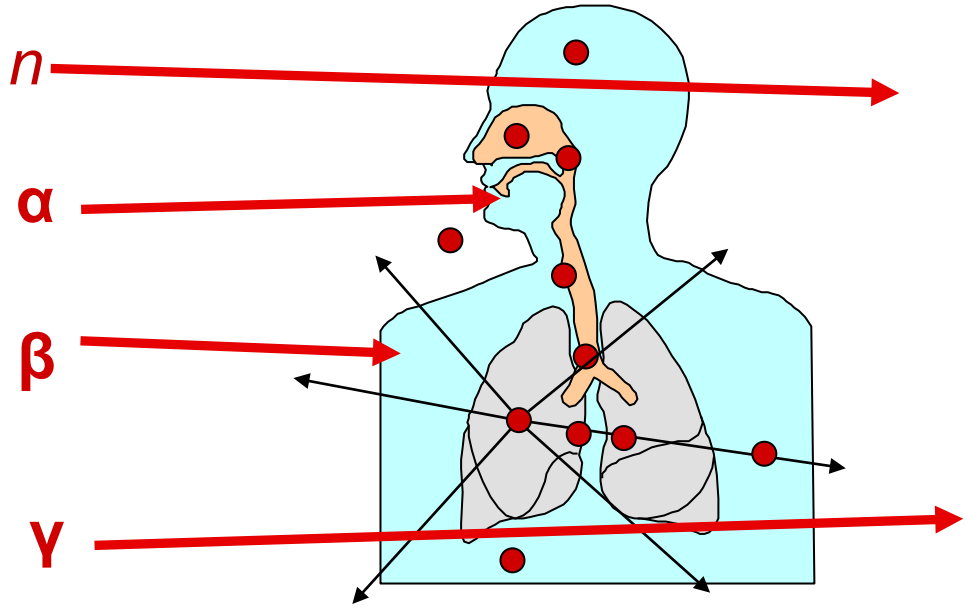
= rad

- Radiation absorbed doses or rads do not account for the risk of the radiation that is ionizing. For example, 1 rad of gamma is less hazardous to cells than 1 rad of alpha.

Units of Measure for Radiation

roentgen equivalent man (rem)

- unit of dose equivalence used for human exposures
- considers the biological effects of different types of radiation on the human body

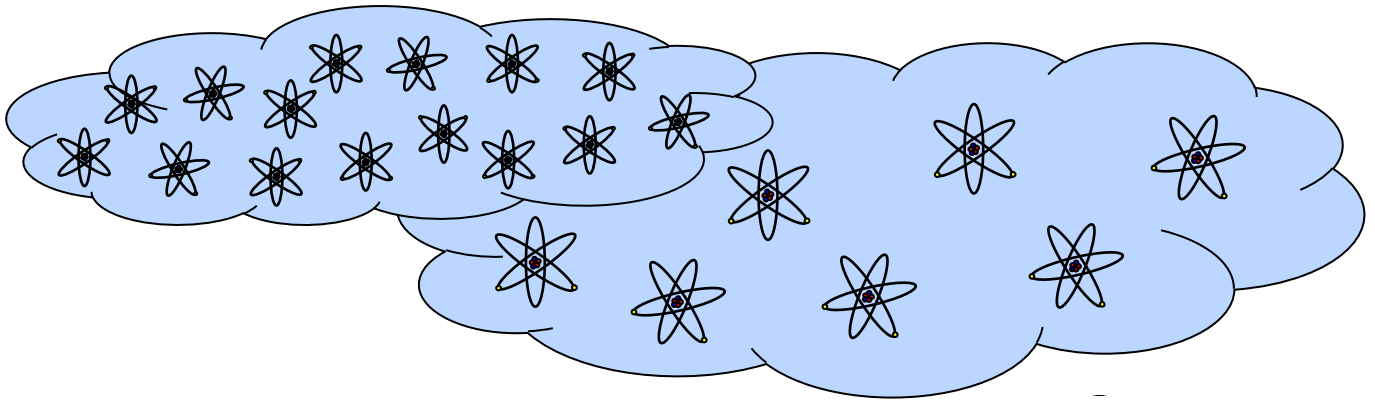


= rem

Units of Measure for Activity and Contamination

Derived air concentration (DAC)

- unit of measure for the amount of radioactive material present per unit volume in air
- the concentration of radioactivity in the air

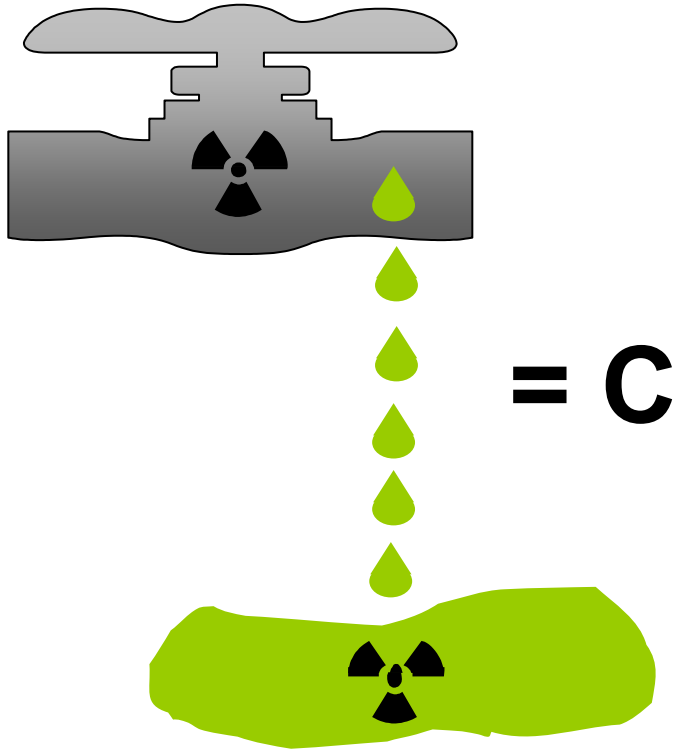


= DAC

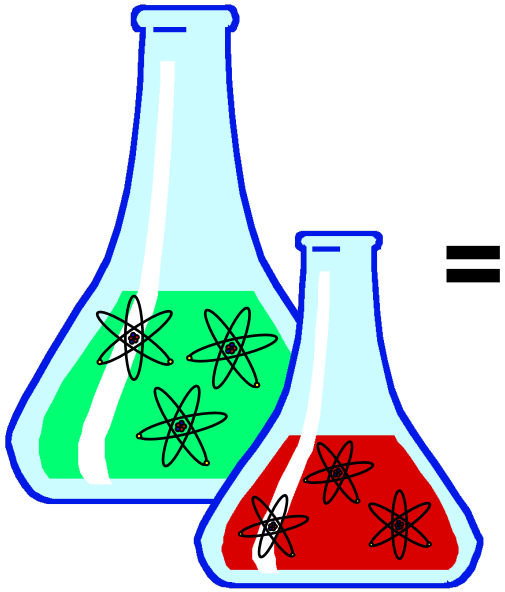
Units of Measure for Activity and Contamination

Basic unit of activity: curie (Ci)

- unit of measure for the amount of radioactive material present



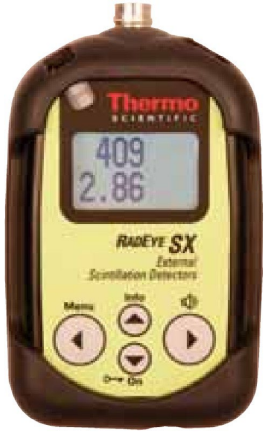
= Ci



= Ci

Units of Measure for Contamination

- Contamination is usually measured in counts per minute (cpm) or disintegrations per minute (dpm).



- Detectors can measure in either cpm or dpm, but it is <u>Reported</u> in disintegrations per minute (dpm) per 100 cm^2 (dpm/100cm^2) by an RCT.

PRE-JOB RADIOLOGICAL CONDITIONS (to be completed by RCT/HPT)

☐ Anticipated radiological conditions (enter anticipated conditions if survey cannot be performed before work begins) or

☒ Measured radiological conditions *(Record all readings as highest/general area.)* ☒ See attached map

Surface Contamination (dpm/100 cm^2)	Direct	Smear	LAS (large area swipe)
Alpha	3000 / 3000	2500 / 2000	NA / NA
Beta/gamma	NA / NA	NA / NA	NA / NA
Tritium		NA / NA	NA / NA

External Dose Rate (mrem/hr in work area)	
Beta + gamma	30 / 5
Neutron	NA / NA
Total (β + γ + n)	30 / 5

Identify anticipated radionuclides: U-235, U-238

Airborne Radioactivity: NA DAC _____ Isotope ☐ Expected or ☐ Measured

Identify any contamination under paint or on inaccessible surfaces: None

Completed by RCT/HPT *(printed name)*	Signature	Z Number	Date
I. M. Tech		0XXXX1	02/06/03

Units of Measure conversion tips

1 rem = 1000 millirem (mrem)

- to convert rem to mrem, multiply by 1000
  - 0.425 rem = 425 mrem

rem x 1000 = mrem

- to convert mrem to rem, divide by 1000
  - 570 mrem = 0.57 rem

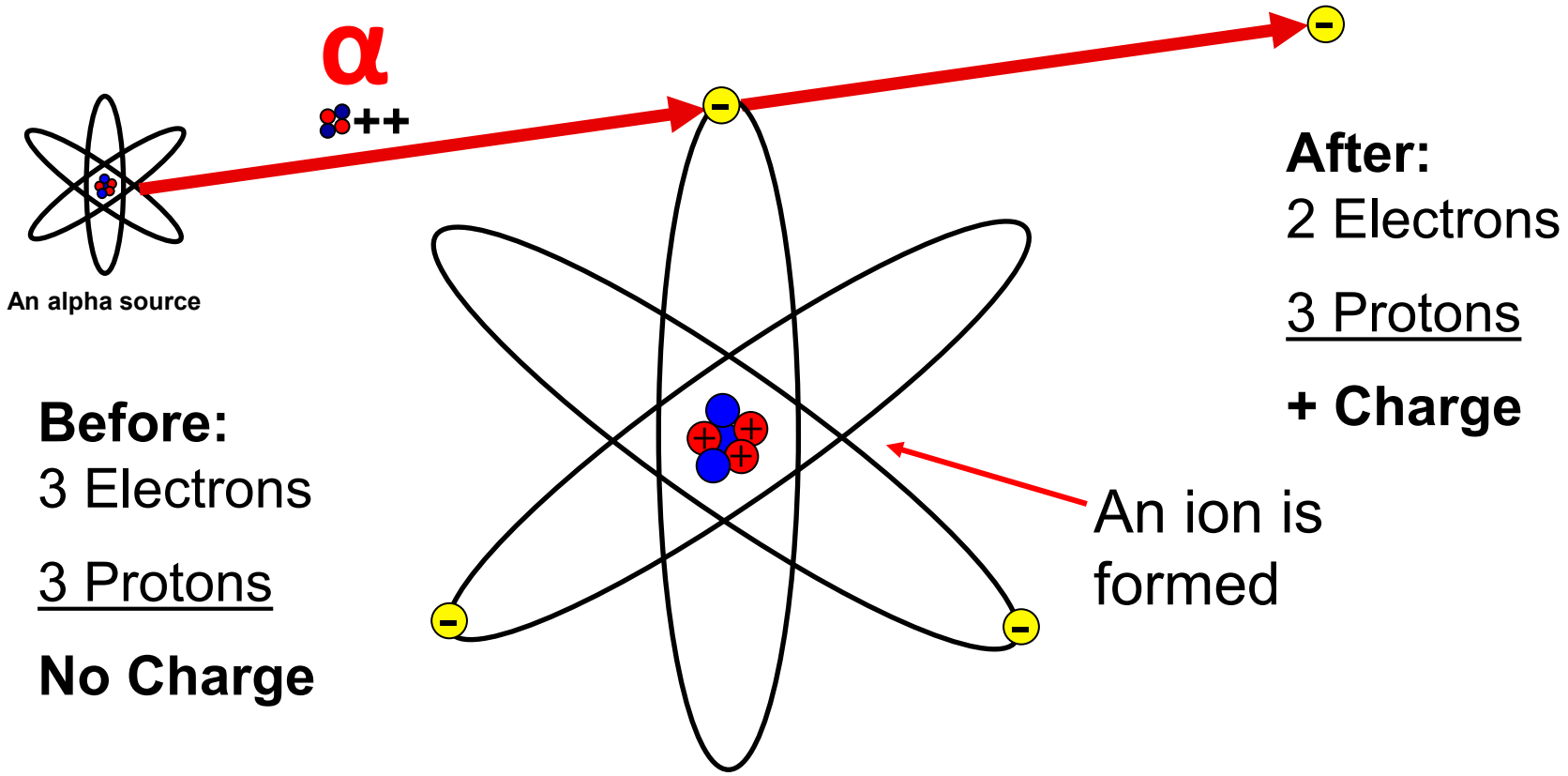
mrem / 1000 = rem

Conversion practice (mrem ↔ rem)

- 3 rem = 3000 mrem
- 13,000 mrem = 13 rem
- 0.26 rem = 260 mrem
- 45 mrem = 0.045 rem

Ionization

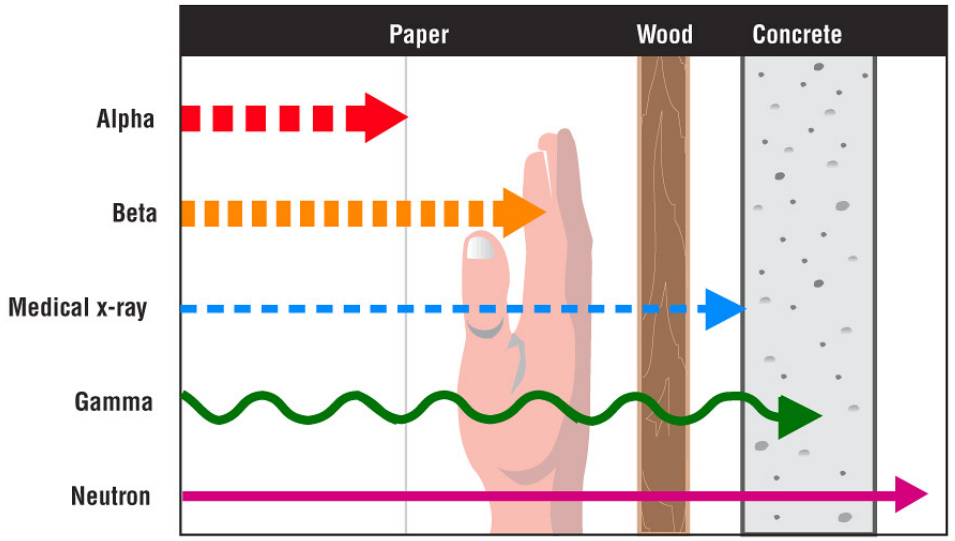
The process of forming an ion by removing an electron from an atom



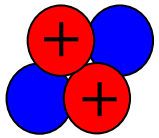
Ionizing Radiation

Ionizing radiation is observed as the following particles/rays. Each has a different amount of energy that it can impart.

- Alpha Particles
- Beta Particles
- Gamma and X-rays
- Neutrons



Alpha Particles



Symbol: **α**

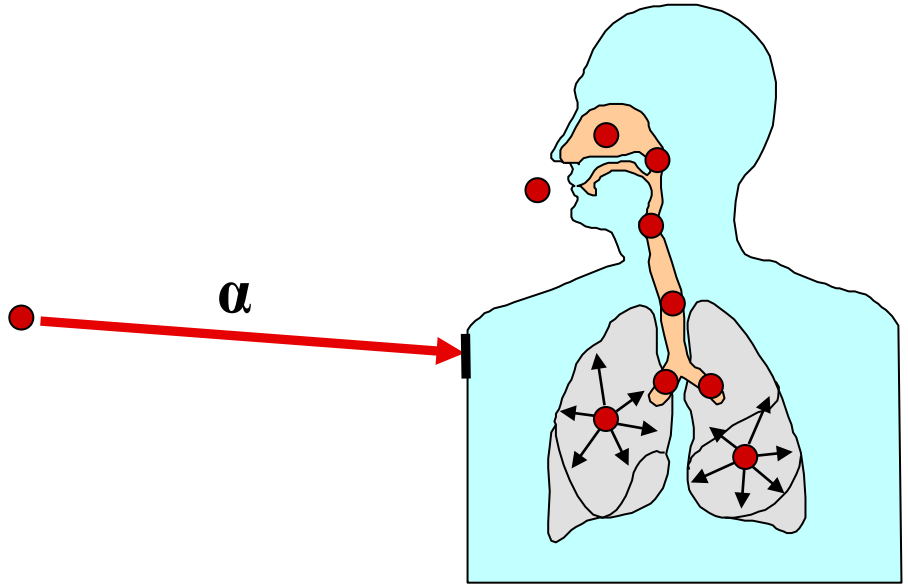
2 Protons

2 Neutrons

+2 charge

What is the range in air?

Short range in air: 1–2 inches



Internal hazard only

- Shielded by:
  - paper
  - outer layer of dead skin

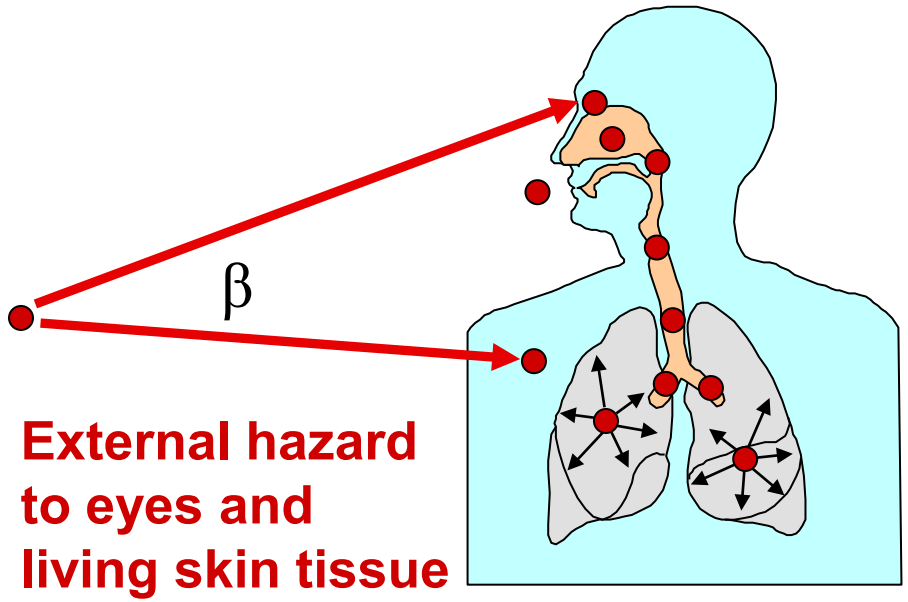
Beta Particles

Symbol: β

Same mass as an electron

-1 or +1 charge

- Short range in air:
  - ~10 feet per MeV (million electron volts)



What is used as shielding material for beta particles?

- Shielded by:
  - plastic
  - aluminum
  - glass

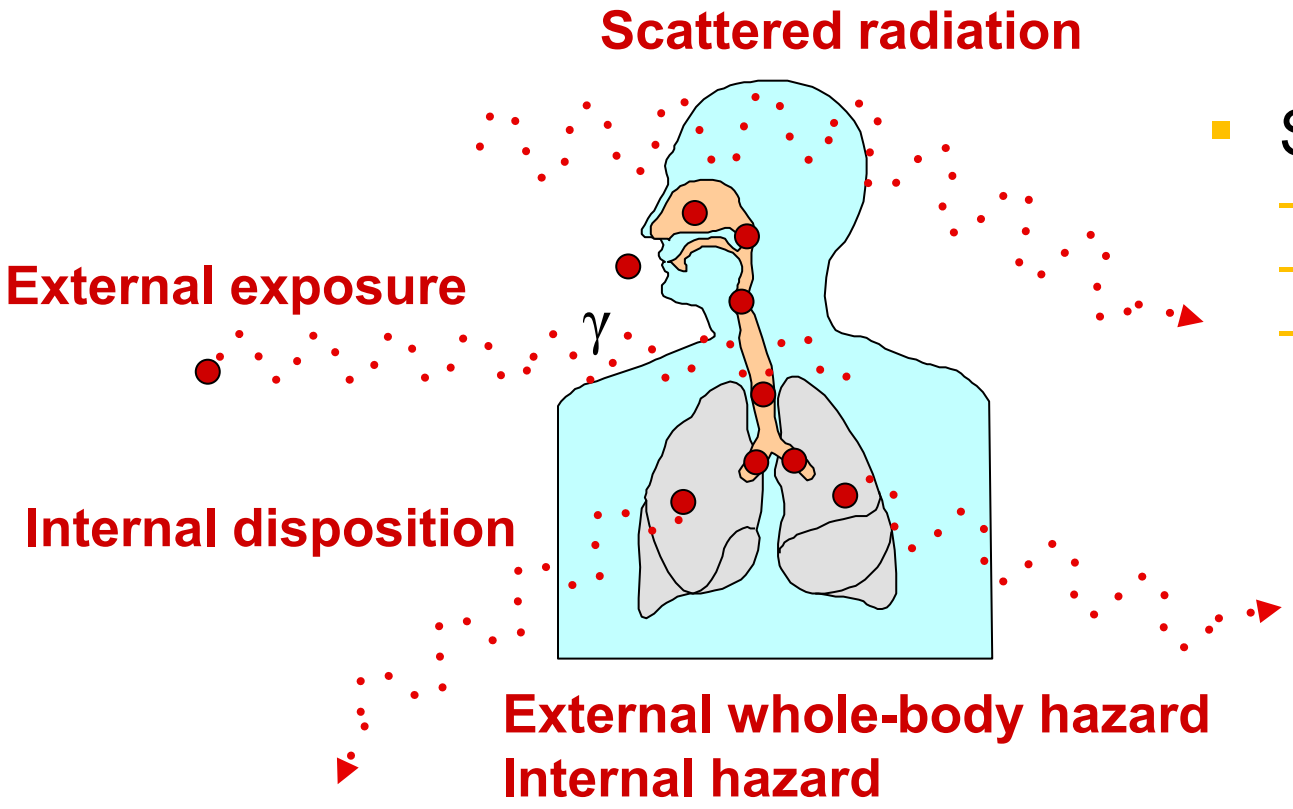
Gamma Rays

Symbol: γ

No mass

No charge

- Long range in air:
  - several hundred feet



- Shielded by:
  - lead
  - steel
  - concrete

EO 1.7

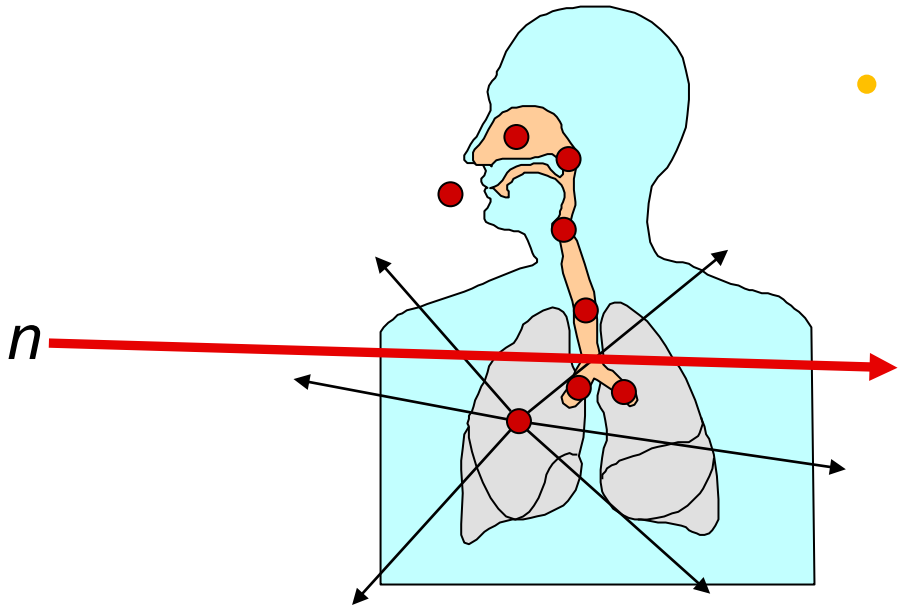
Neutron Particles

Symbol: *n*

Same mass as a proton

No charge

- Long range in air:
  - several hundred feet

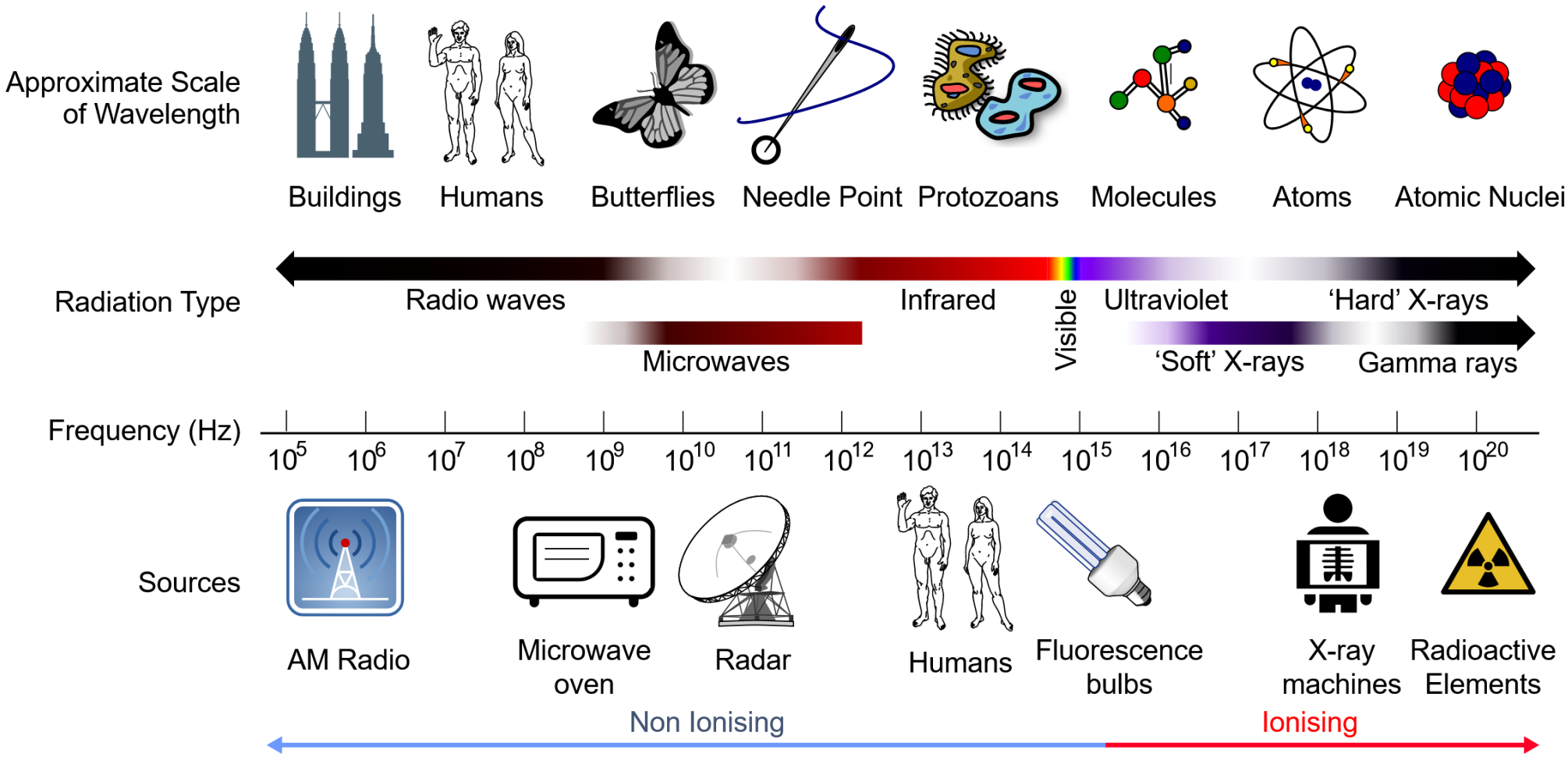


- Shielded by:
  - water
  - plastic (polyethylene)
  - materials containing lots of hydrogen atoms

External whole-body hazard
Internal hazard

EO 1.7

Electromagnetic spectrum- non-ionizing vs ionizing radiation



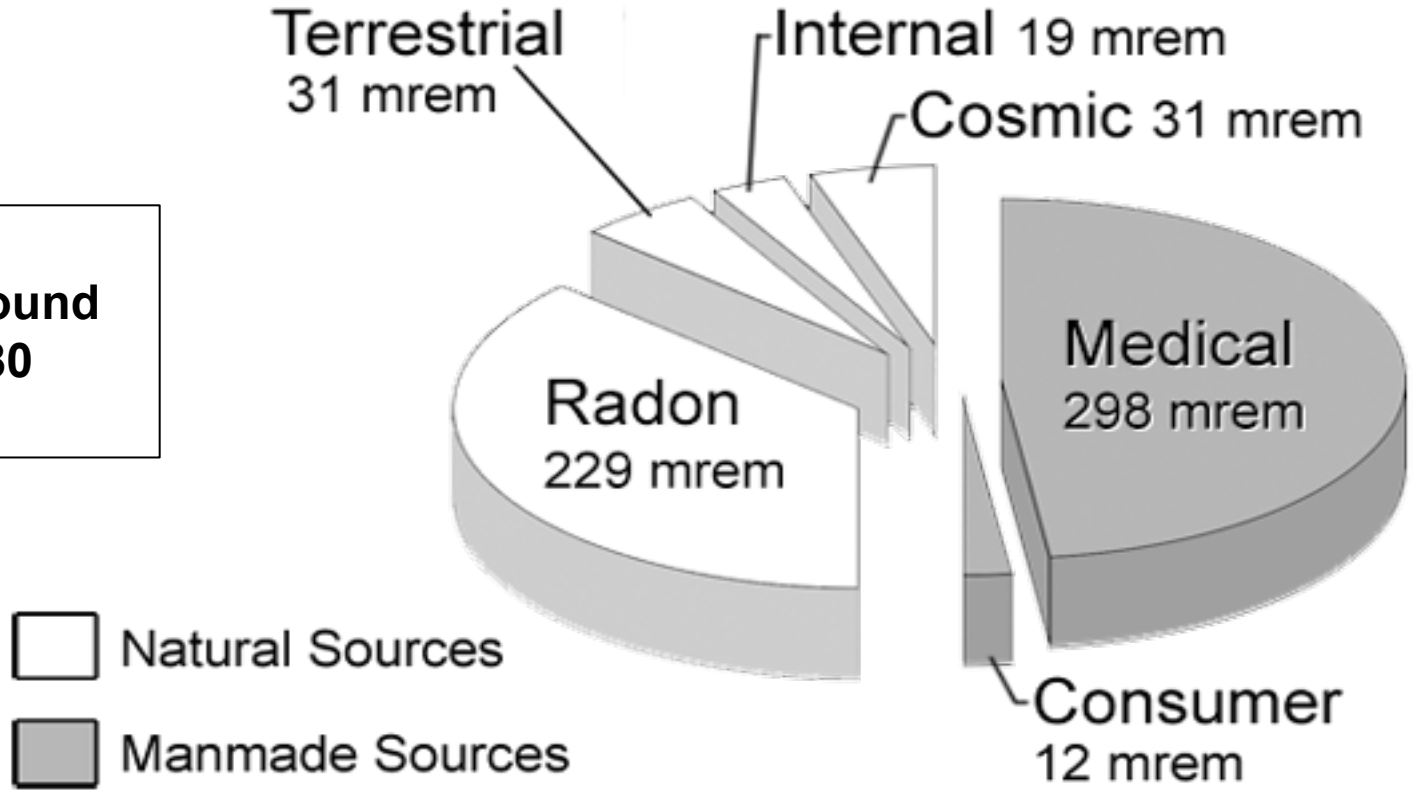
Note: All the waves on the electromagnetic spectrum are photons with varying energies

EO 1.7

Background Radiation

Average nationwide dose is 620 mrem

The Los Alamos average background dose is about 780 mrem. Why?



Sources of Radiation

Consumer product examples

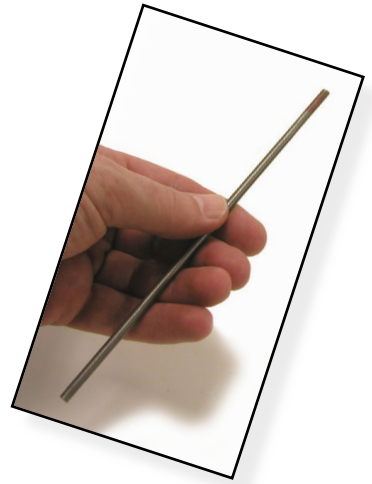
Orange Fiesta® Ware

Camera lenses

Salt substitute

Cloisonné enamelwork

Smoke detectors



Welding rod

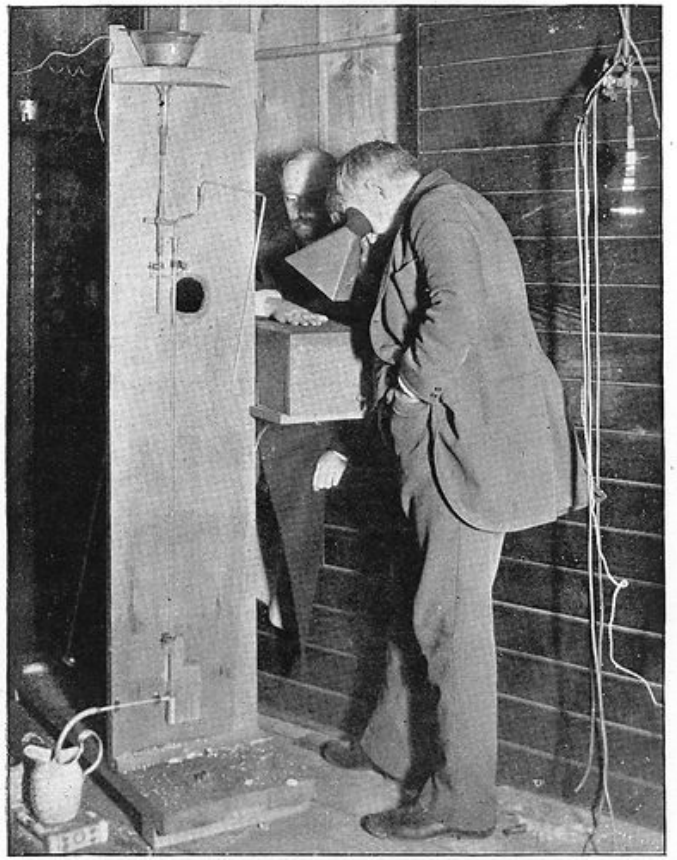
EO 1.8

Biological Effects

- Information about the biological effects of radiation on the human body is available from
  - early workers
  - atomic bomb survivors
  - radiation accident victims
  - radiation therapy patients

Biological Effects to Early Workers- Lessons Learned

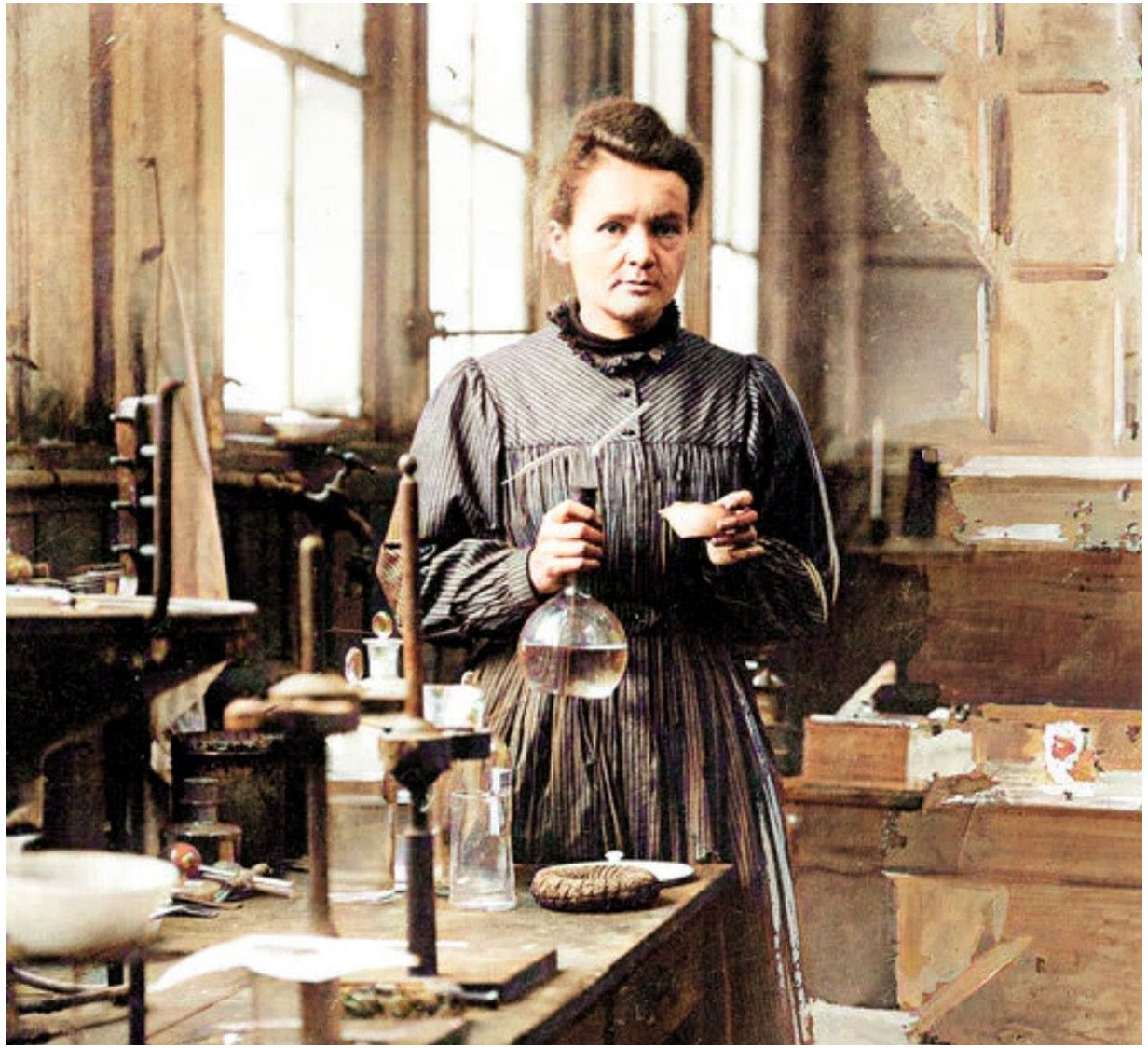
- Clarence Dally (1865–1904)
  - Dally made x-ray tubes for Thomas Edison.
  - His radiation dose led to amputations of fingers, hands, and arms.
  - He died in 1904, less than 10 years after the first paper on x-rays was published in 1896 by Wilhelm Conrad Röntgen (Roentgen).



EO 1.7, 1.8

Biological Effects to Early Workers- Lessons Learned

- Radium dial workers (late 1910s)
  - Workers painted dials with radium paint to make them glow in the dark.
  - They were never told of the hazard.
  - Women would sometimes paint their teeth and nails to surprise their boyfriends.
  - They began to develop bone cancers in the 1920s.



EO 1.7, 1.8

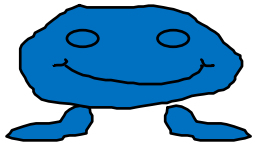
Consequences of Cell Damage

As the amount of radiation to the cell increases, the cell may become overwhelmed, resulting in cell death or damage (mutation) that could cause future problems even years later (cancer).

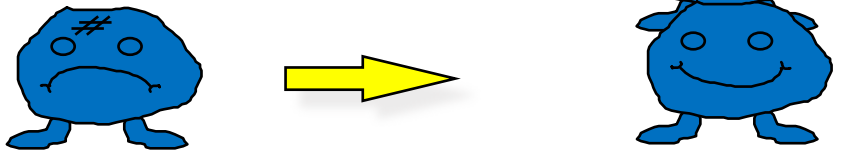
Possible effects on cells:

- Some cells are not affected (no damage done)
- Most cells repair the damage
- Some cells die as a result of the damage
- Misrepair of DNA or “damaging alteration”(mutation)

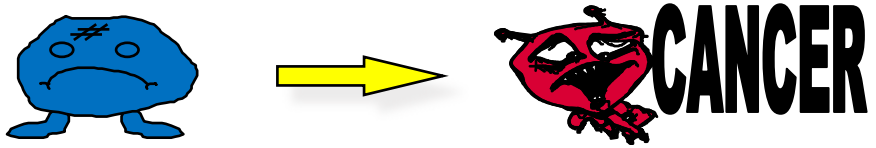
Nothing happens



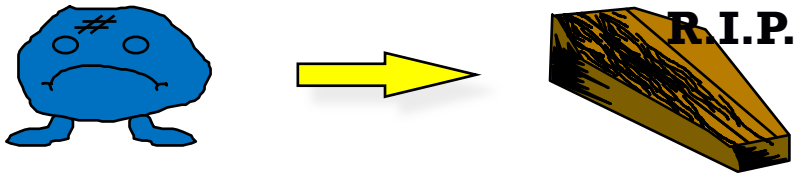
Cell repairs itself



Cell is damaged or mutates



Cell dies



EO 1.7, 1.8

Radiation Damage to Cells

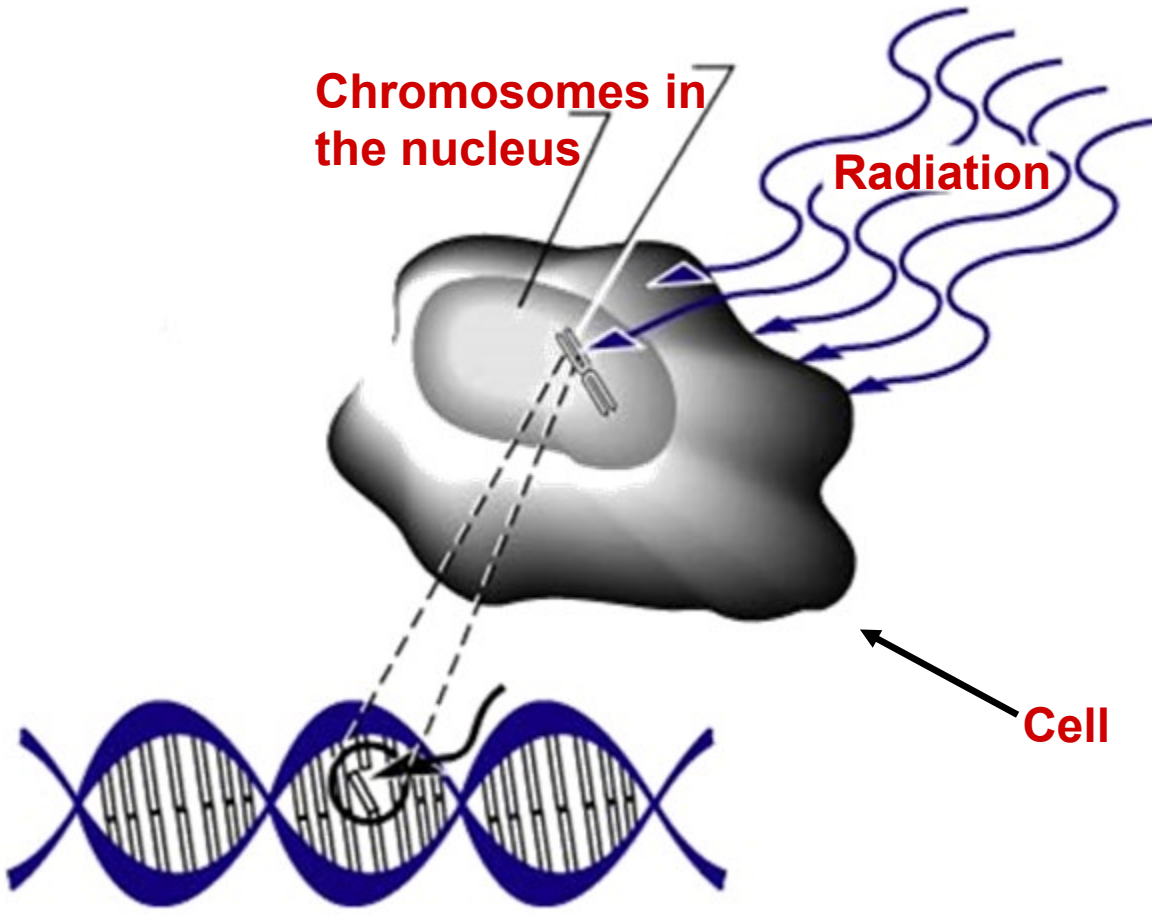
The nucleus is the most sensitive portion of the cell with respect to the effects of radiation exposure

The nucleus contains our chromosomes, inside of which is located the very important molecule, DNA

Radiation can break molecular bonds in DNA, which can result in damage to our genetic information

The effects of chromosome damage in a cell resulting from exposure to radiation can be:

- Somatic (bodily)
- Heritable (if damage is in the egg or sperm)



EO 1.7, 1.8

Types of Biological Effects

- **Somatic effect**
  - occurs in the individual exposed to the radiation

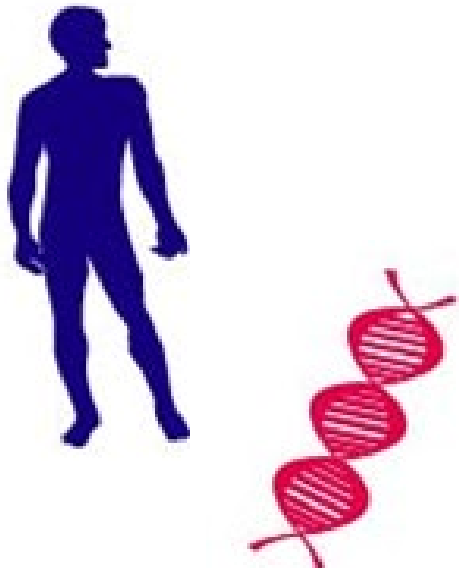
"What is exposure going to do to ME?"

- **Heritable effect**
  - is passed on to the offspring of the individual exposed to radiation

"What is exposure possibly going to do to future generations (No heritable effects have been seen in people but have been seen in plants and animals)"

Factors Affecting Biological Damage

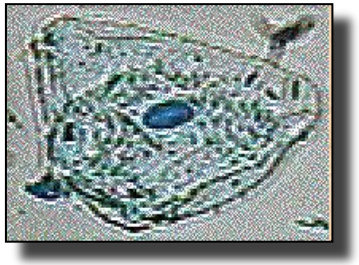
- Total ionizing radiation dose
- Type of radiation
  - Alpha and Neutron typically cause the most damage
- Radiation dose rate
- Area of body exposed
  - Cell sensitivity
  - Tissue sensitivity
- Individual sensitivity



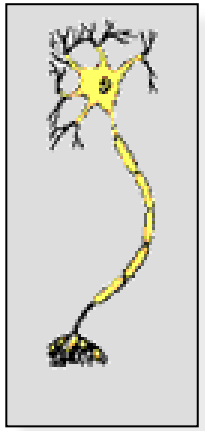
EO 1.7, 1.8

Cell Sensitivity

- Actively dividing and nonspecialized cells are more sensitive to radiation. Examples include:
  - blood-forming cells
  - hair follicles
  - lining of the lungs
  - embryo/fetus
  - intestinal tract cells



- Less-actively dividing and specialized cells are less sensitive to radiation. Examples include:
  - brain cells
  - muscle cells



EO 1.7, 1.8

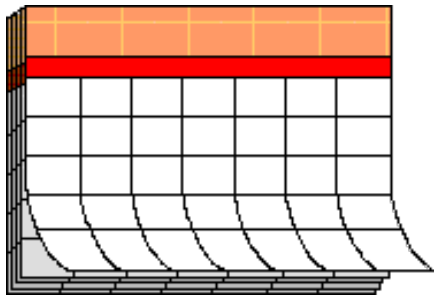
Radiation Dose Rate

"What is an acute dose?"

- Acute dose
  - Radiation dose received in a short period of time
  - Typically, a relatively large amount of radiation

"What is a chronic dose?"

- Chronic dose
  - Radiation dose received over a long period of time
  - Typically, a relatively low level of radiation
    - (0.62 rem x 75 years) = 47 rem



Effects of Acute Dose to the Whole Body

- ≈0–25 rad: no detectable effect
- ≈25–100 rad: temporary blood changes
- ≈100–200 rad: nausea, vomiting, and diarrhea (first symptoms of radiation sickness)
- ≈200–300 rad: probable radiation sickness
- ≈300–600 rad: possible death without medical treatment
- ≈600–1000 rad: probable death
- >1000 rad: death

Chronic Dose Risk

- Although widely thought of as a cause of cancer . . .

- The risk of exposure to chronic low levels of radiation (background or occupational doses) is **not** precisely known.

- Acute radiation exposure **may contribute** to a limited increase in cancer risk.

EO 1.7, 1.8

Unit 2:
Radiation Dose Limits and Administrative Control Levels

Objectives Unit 2

- EO 2.1. Explain the basis and purpose of DOE federal dose limits
- EO 2.2. Define terms related to radiation dose limits
- EO 2.3. Explain the risks of radiation exposure to pregnant workers
- EO 2.4. Explain the use of ACLs

Dose Limits and Administrative Control Levels

- Radiation protection standards assume that any radiation dose causes an increased risk of negative health effects.
- DOE has established dose limits* at DOE sites to minimize the possible biological effects caused by radiation exposure.

  * These limits are virtually identical across the globe

- Administrative Control Levels (ACLs) are placed at facilities to provide another level of protection to workers. At LANL ACLs are place at 2 rem compared to the DOE dose limit of 5 rem whole body.
- Action levels are also placed at levels lower than the ACL in order to create stops in work to reassess the work being done.

Dose Limits

DOE Dose Limits, ACLs and Action Levels at LANL			
Type of Exposure	**Dose Limits**	**ACL**	**Action Level**
Rad Worker Whole body (Internal + external)	5 rem/year	2 rem/year	1 rem/year
Rad Worker Lens of the eye (external)	15 rem/year	N/A	3 rem/year
Rad Worker Skin and Extremities (Internal + external)	50 rem/year	N/A	10 rem/year
Rad Worker organs or tissue (Internal + external)	50 rem/year	N/A	10 rem/year
Declared pregnant worker: embryo/fetus (Internal + external)	0.5 rem/gestation period	N/A	0.1 rem/year
Minors: Whole Body	0.1 rem/year	N/A	N/A
Minors: Lens of the eye, skin, extremities	10% of rad worker	N/A	N/A
General employee (non-radiological worker) Whole body	0.1 rem/year	N/A	N/A
Member of the public Whole body	0.1 rem/year	N/A	N/A

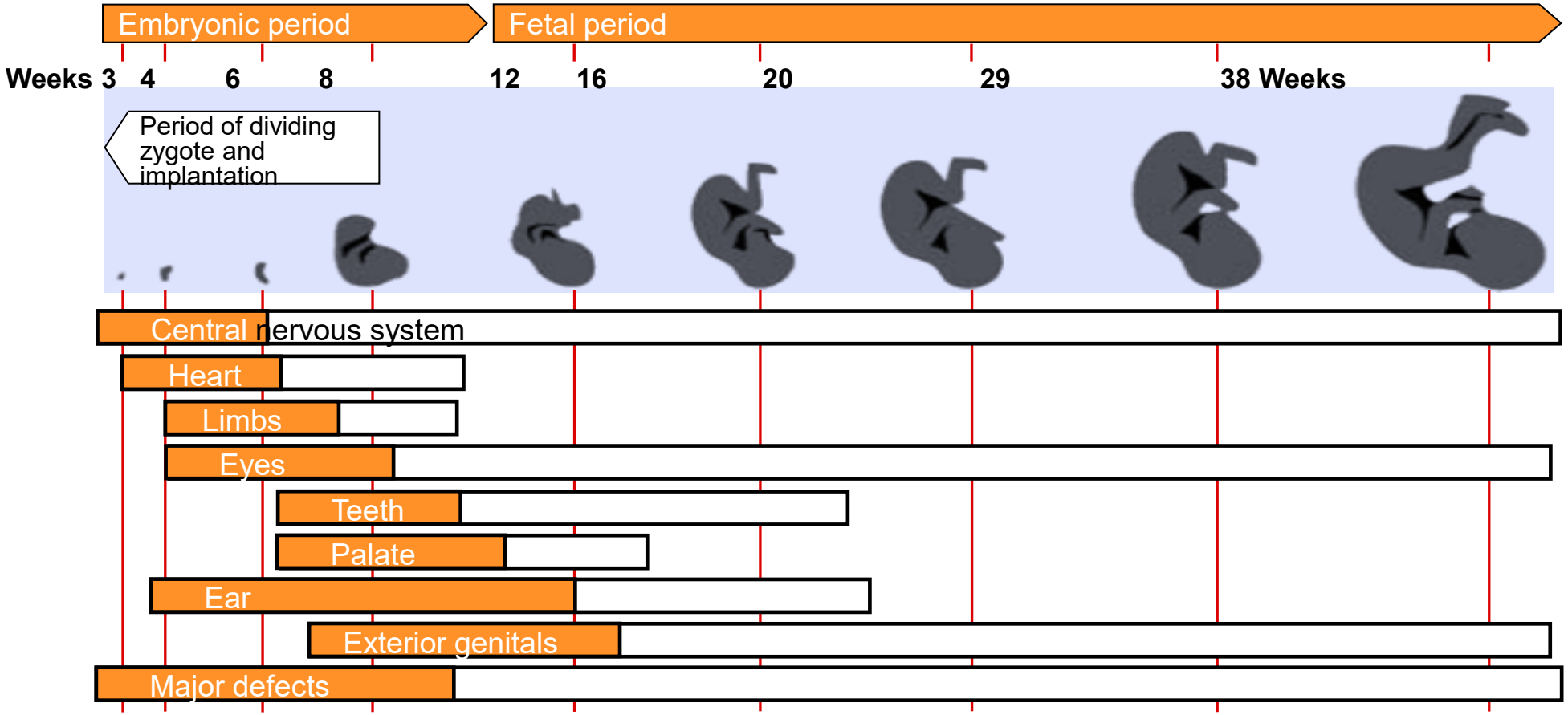
- Whole body
  - Top of the head to the elbows and knees
- Extremities
  - Arms below the elbow
  - Legs below the knee
- Organs
  - Group of tissues that together perform one or more definite functions
  - Examples include lungs, liver, kidney, skin, and bone

EO 2.2, 2.4

Pregnant Workers Radiation Exposure

- The most sensitive time of pregnancy is the first trimester as this is when the major organ systems are forming.

- Pregnant workers are encouraged to notify LANL as early as possible about pregnancy so LANL can work to help protect the developing baby and the parent.



EO 2.3

Prenatal Exposure Risks

- Low birth weight
- Small head size
- Intellectual Disabilities
- Possible increased risk of childhood cancer

No heritable effects have been observed in children *conceived after exposure – this would be a genetic effect, not prenatal exposure*.

- What is the dose limit for an embryo/fetus?

500 mrem for entire pregnancy (9 months)

Declaration of pregnancy is not a requirement – it's the mother's choice.

Your Responsibilities

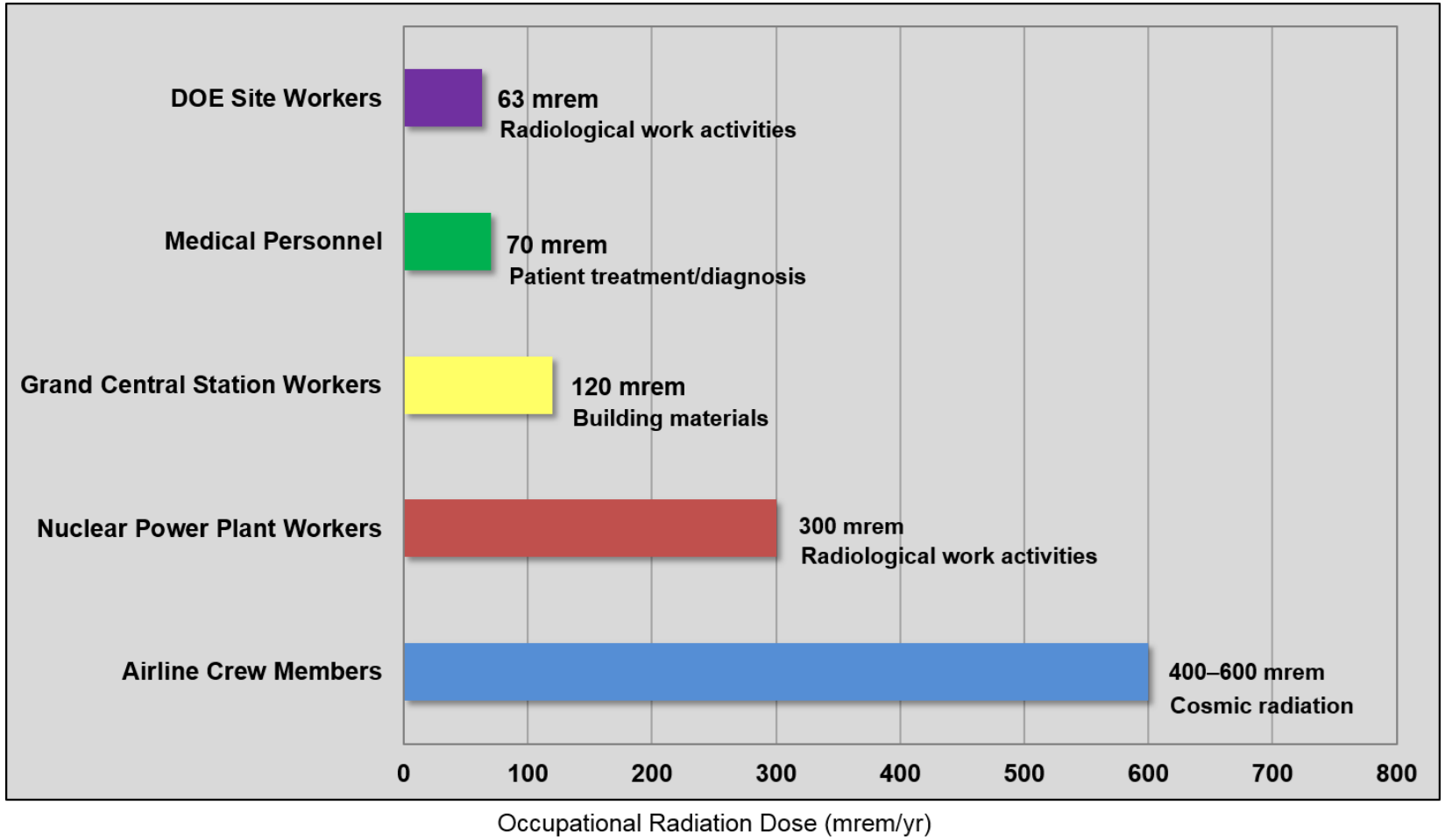
- Comply with radiation dose limits
- Comply with radiological control rules
- Recognize the impact of one's actions
- Notify supervisor if dose limits are being approached

EO 2.1

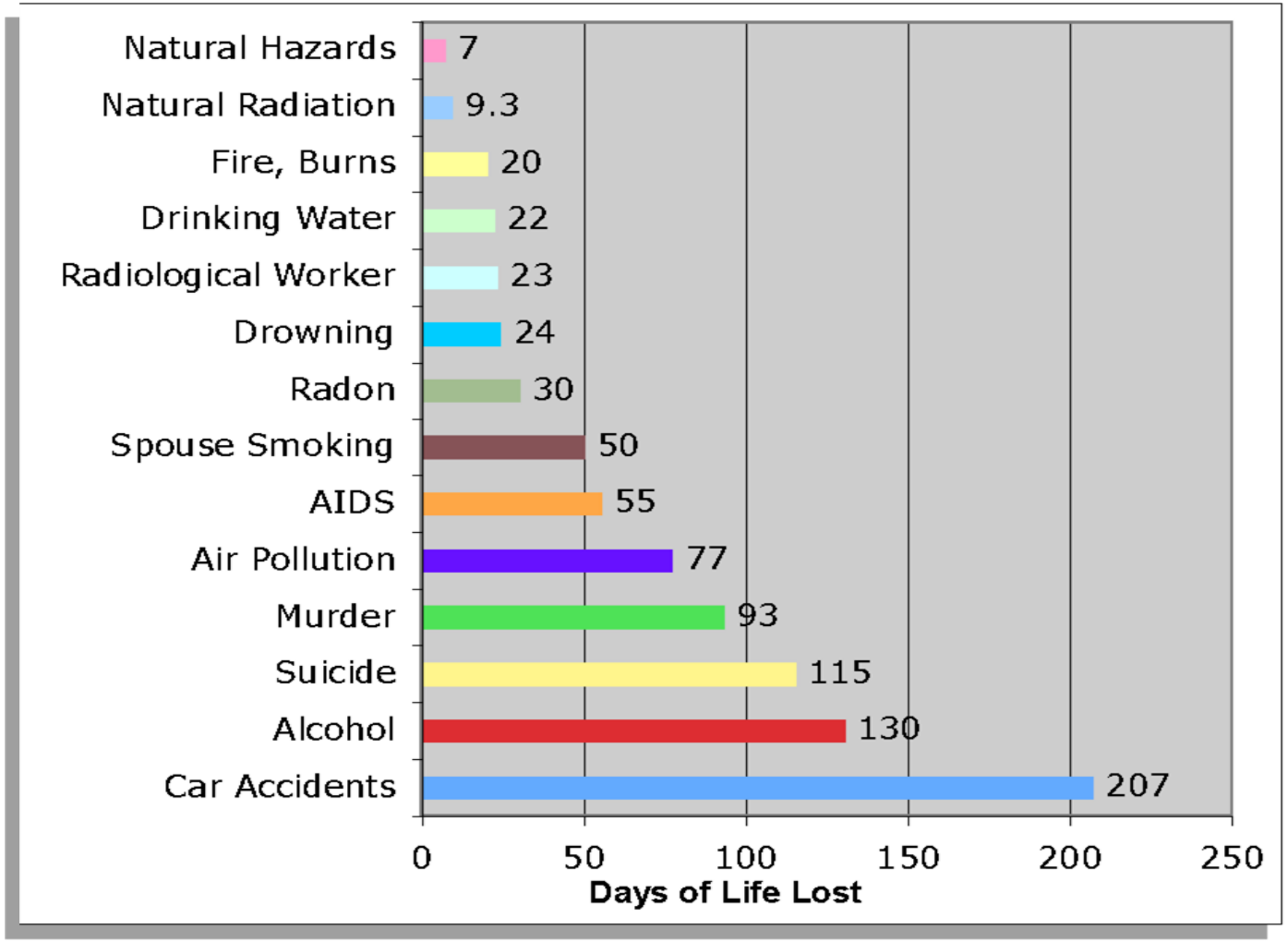
Comparing Occupational Risks

Occupation	Days Lost from Life Expectancy
Demolition	1500
Coal or uranium mining	1100
Fire fighting	800
Railroad	500
Agriculture	300
Construction	200
Transportation/public utilities	160
Average of all occupations	60
Government	55
Radiation dose of 1000 mrem per year	50
Service	45
Trade	30
Single radiation dose of 1000 mrem	1.5

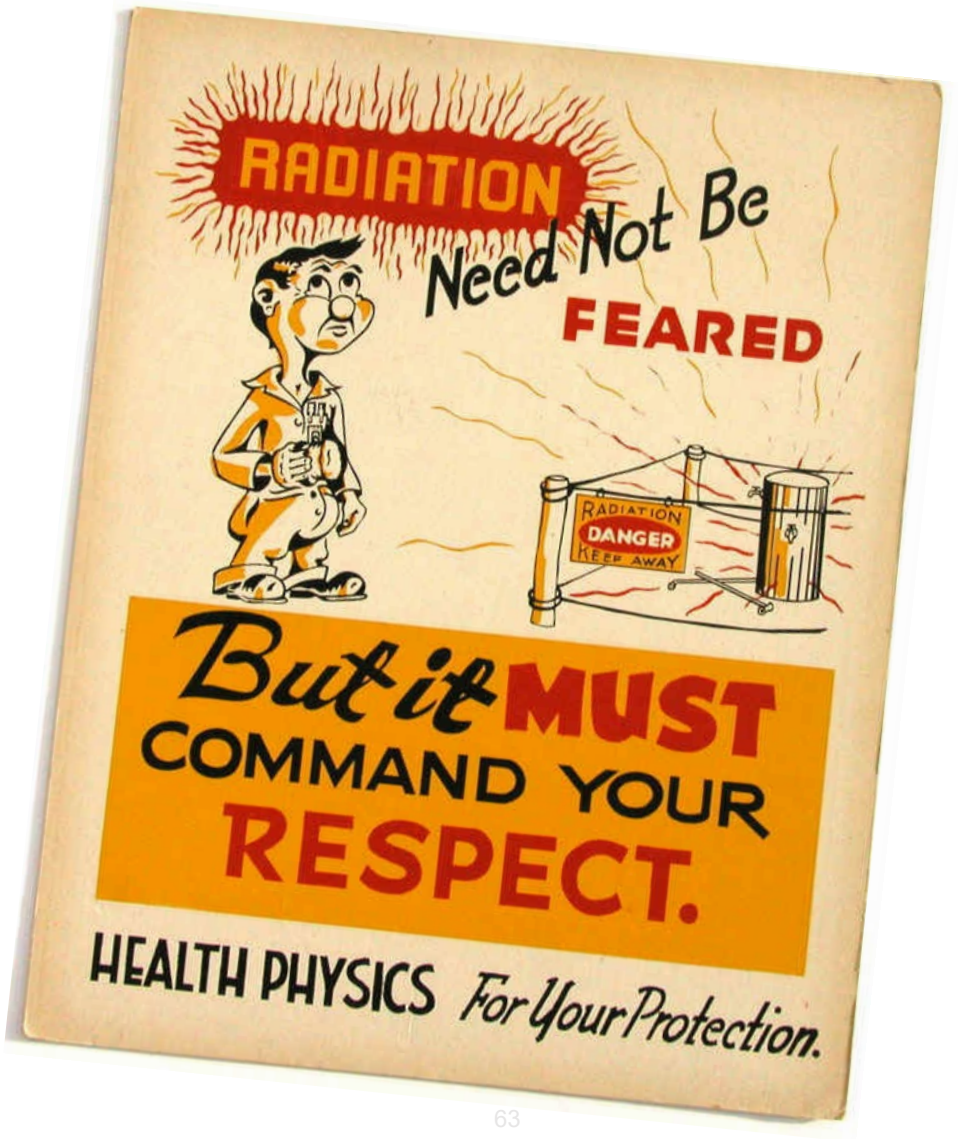
Comparing Occupational Dose



Days of Life Lost from Life Expectancy



Unit 3: ALARA


RADIATION
Need Not Be
FEARED
RADIATION
DANGER
KEEP AWAY
But it MUST
COMMAND YOUR
RESPECT.
HEALTH PHYSICS For Your Protection.

Objectives Unit 3

- EO 3.1. State the purpose of the ALARA concept as it applies to occupational radiation exposure
- EO 3.2. Identify the responsibilities of the radiological worker and others as it applies to the ALARA concept
- EO 3.3. Identify methods for reducing external radiation dose
- EO 3.4. Identify methods for reducing internal radiation dose
- EO 3.5. Identify the requirements for shipping, receiving, labeling, and working with radioactive material
- EO 3.6. Identify the requirements for removal of waste from an RCA that is controlled for contamination

ALARA

As
Low
As
Reasonably
Achievable

DOE Management ALARA Policy

Radiation exposure

- MUST be maintained ALARA
- MUST be kept well below regulatory limits

"No radiation exposure to workers or the public should occur without receiving commensurate (equal) benefit based on sound economic principles."

LANL Policy on Lifetime Dose

LANL's policy states that workers must keep the amount of their lifetime doses (in rem) less than their ages (in years).

Example: You have worked for LANL for 30 years and you are 50 years old.
According to the DOE you should be able to have the following dose.

30 yr x 5 rem/yr DOE dose limit = 150 rem

However, the LANL Lifetime Dose Policy requires that your dose rate must be less than how many rem?

At age 50, your radiation dose should be less than 50 rem.

Management Responsibilities

- Implement ALARA requirements within their area of responsibility
- Promoting an ALARA attitude
- Establishing and supporting an ALARA point-of contact
- Review and approve ALARA goals
- Assign responsibilities to ensure ALARA is accomplished day-to-day
- Investigate unusual exposure events
- Review personnel exposure data to plan workload
- Establish training requirements
- Promote ALARA awareness and ensure workers know responsibilities and possible hazards

RCT's Responsibilities

- Conduct radiological surveys
- Provide information on radiological conditions
- Implement requirements
- Specify exposure and contamination controls
- Answer radiological questions and address concerns
- Stop work when conditions are unsafe

Radiological Worker Responsibilities

- Maintain radiation dose ALARA by knowing dose limits and your remaining dose
- Know the area radiological conditions
- Read and obey posted, written, and oral instructions such as signs, RWPs, IWDs, SOPs, and RCTs' instructions
- Participate in pre-job briefings and post-job reviews
- Report any radiological or safety problems
- Use your "stop work" authority when conditions or work practices are unsafe

Reducing External Radiation Dose

Basic Protective measures can be taken to reduce external radiation

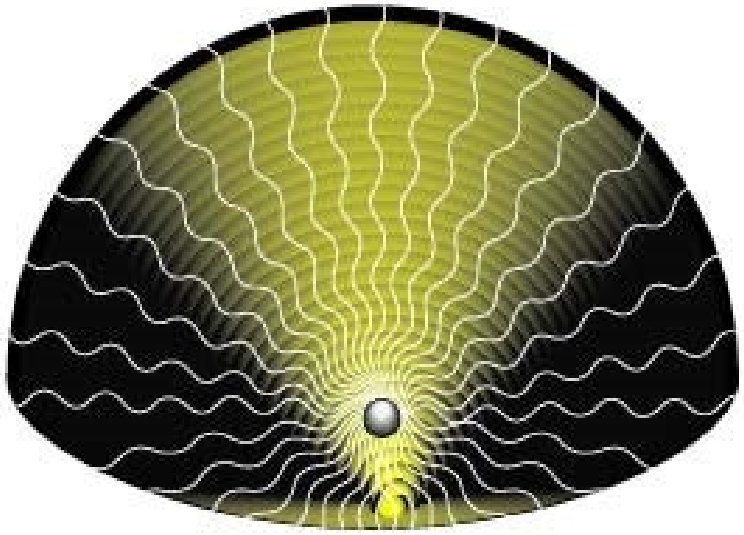
- Minimize time in a radiation field
- Maximize distance from the source of radiation
- Use appropriate shielding when practical
- Use source reduction, when appropriate

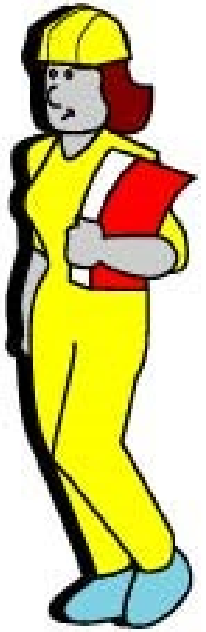
Minimize Time

- Plan and discuss task prior to entry
- Have all tools needed prior to work
- Use mockups and practice runs
- Exit radiological area as soon as work is done
- Work efficiently but swiftly
- Do the job right the first time
- Perform as much work as possible outside the area
- Observe stay time if a time has been assigned

In

Out



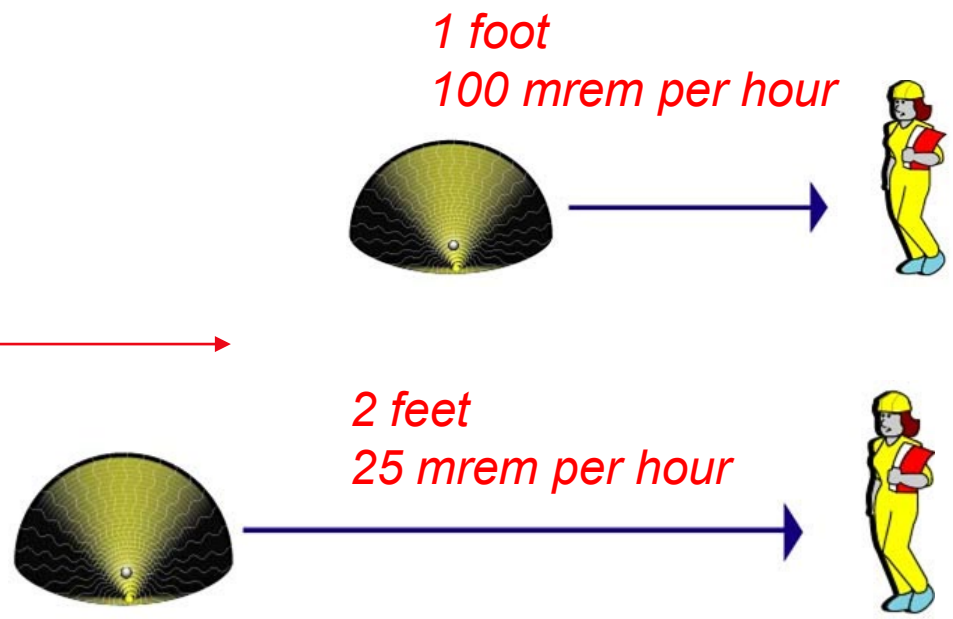


EO 3.3

Maximize Distance

- Stay as far away from sources of radiation as practicable
- Be familiar with the radiological conditions and the sources of radiation
- During delays or when waiting, move to lower dose areas
- Carry radioactive material at a distance from your body
- If possible, move work to an area with a lower dose rate

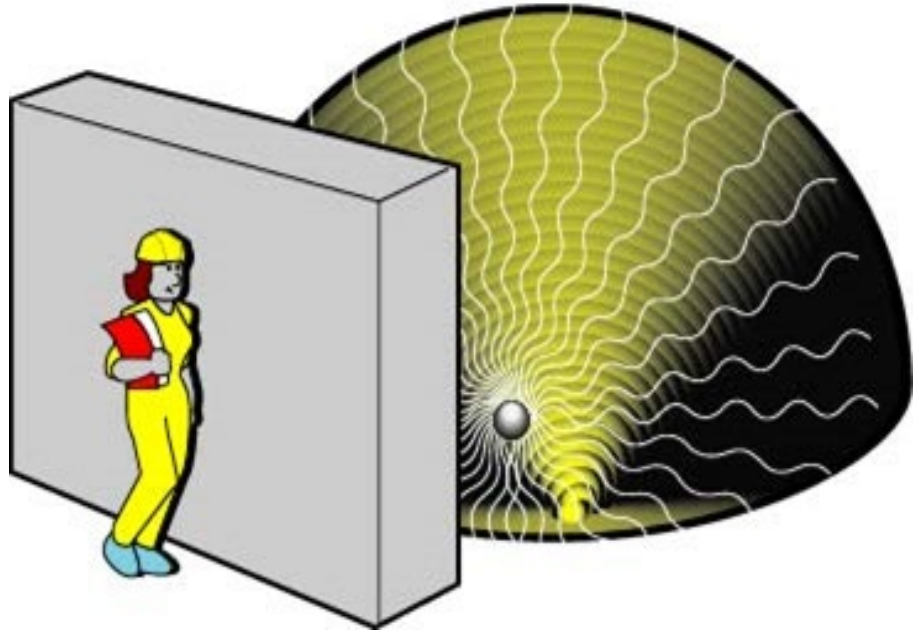
Inverse Square Law
Doubling the distance cuts the radiation to 1/4



EO 3.3

Proper Use of Shielding

- Take advantage of permeant fixtures
- Use available shielded containment such as glove boxes
- Wear specific safety glasses or googles when applicable
- Use temporary shielding ex. Lead or concrete blocks when approved
- Use shielding appropriate for the radioisotopes in the work area



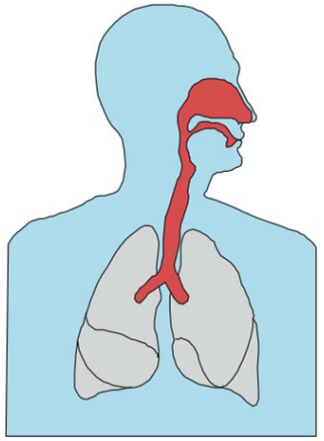
Methods of Source Reduction

- Flush components or piping systems with clean water before performing maintenance activity
- Drain pipes, tanks, or components that contain residual contaminated liquid
- Remove packaged radioactive material from the work area

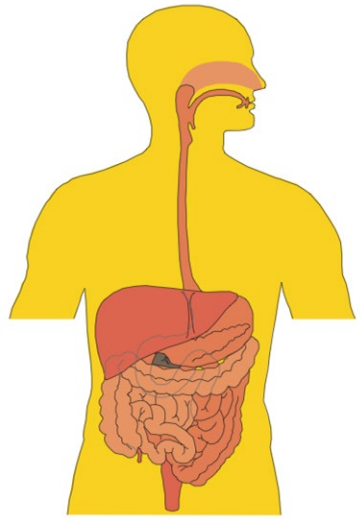
Reducing Internal Radiation Dose- Routes of Entry

Internal exposure is the result of radioactive material entering the body by:

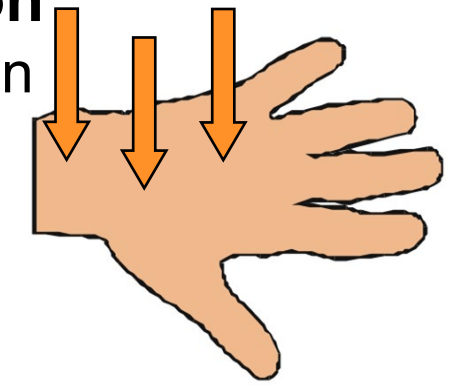
Inhalation
Breathing
Smoking



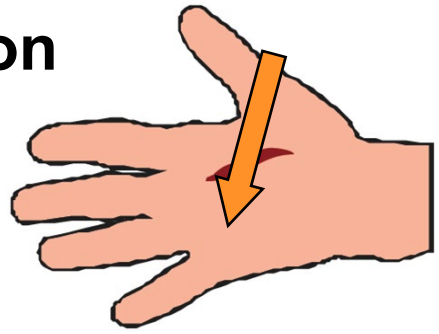
Ingestion
Eating
Drinking
Chewing



Absorption
through skin



Absorption
through
wounds



EO 3.4

Reducing Internal Radiation Dose

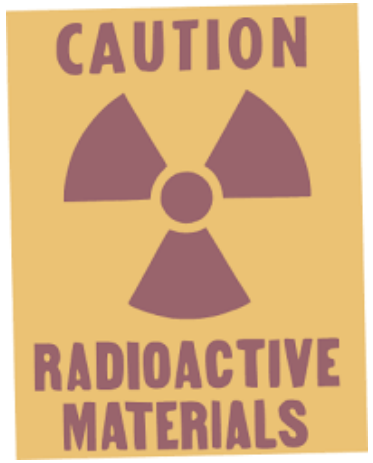
- Report all wounds, cuts, scabs, or rashes to your RCT before starting work
- Wear PPE as required
- Wear respirators properly and when required
- Comply with work document requirements
- Do not eat, drink, smoke, chew, or apply cosmetics or lip balm in controlled areas
- Use extra caution with sharp tools
- Immediately report any injuries to the RCT

Working With Radioactive Material

Radioactive material exists in many forms it may be:

- Solid (metal, powder, etc.)
- Liquid
- Gaseous
- Vapor

It can be stored in many ways, in containers or as a sealed source. No matter what form the material is in or the container, steps must be taken to control the use and movement of radioactive material.



Labeling of Radioactive Material

- Individual containers of radioactive material and/or radioactive items must be labeled
- Packaging of items having removable surface contamination in excess of designated values by procedures must be labeled when used, handled, or stored in areas other than
  - Contamination Areas
  - High Contamination Areas
  - Airborne Radioactivity Areas
- Labels must be applied to the outside of the package or be visible through the package and must have a warning trefoil and the words Caution or Danger and radioactive material
- A tag may be used by an RCT to meet the labeling requirements. Additional information may also be required
- Tags must
  - be used only temporarily (for removal, transport, or short-term holding of items)
  - be completed by RP
  - NOT be used in conditions that could degrade the tag or its legibility

Radworker Responsibilities for Labels & Tags

- The radworker's responsibilities regarding radioactive material labels and tags are to
  - read ALL radioactive material labels, tags, and postings
  - report any missing or illegible tags to the RCT
  - follow ALARA principles and other radiation protection requirements when handling radioactive material
- If you have any problems or concerns, contact the RCT before handling any radioactive material

Packaging & Storing Radioactive Material

- Radioactive material may be stored in radiological areas, RBAs, RCAs, or uncontrolled areas, if the labeling and posting requirements for radiological hazards are met.
- For radioactive material used or stored in uncontrolled areas, the material and its intact packaging must not present the potential for 100 mrem/yr external dose or contamination above the levels defined in the appropriate procedures.
- If radioactive material will be used or stored in an uncontrolled area, an RP SME must evaluate the conditions to ensure that these criteria are met.
- Radioactive material must be packaged and stored so that the package does not leak.
- As an ALARA measure, package contents should be readily identifiable and items with loose surface contamination within Contamination Areas, High Contamination Areas, or Airborne Radioactive Areas should be contained.

Shipping & Receiving from Transportation

- An RCT must perform receipt surveys of radioactive material shipments when received at the central shipping and receiving warehouse and at the final destination facility before the shipping vehicle leaves that facility.
- When outer transport containers of radioactive material are initially opened following receipt, an RCT must be present to perform surveys to ensure no unanticipated conditions exist (i.e., contamination on inner packaging).
- Receipt surveys are required for
  - waste shipments
  - accountable sealed sources or radioactive material required to be labeled
  - any 10 CFR 835 threshold that requires receipt survey
  - large items with the potential for contamination
  - a package containing radioactive material of any type or quantity that arrives damaged (e.g., crushed or wet)
  - other radioactive material (except for limited exceptions)

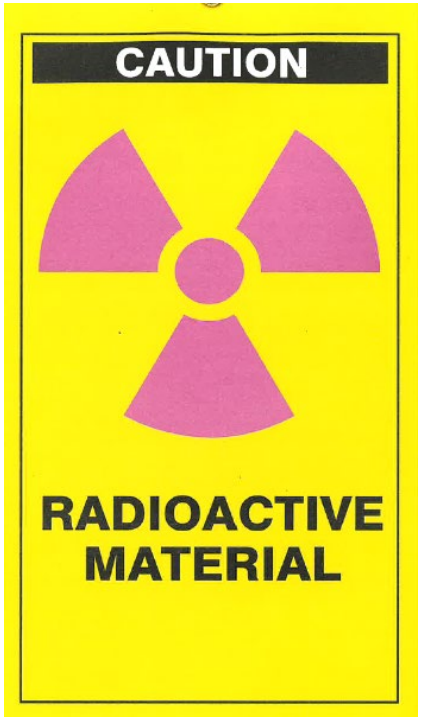
When in doubt, consult with your RCT

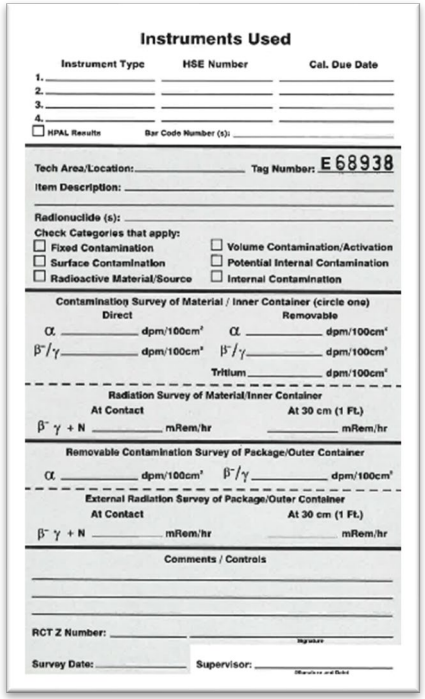
HPRMS Tags

Health Physics Radioactive Material Survey (HPRMS) tags are used to label radioactive material that is being stored or shipped both within and out of LANL. It is pertinent that Radiological workers are aware of the purpose HPRMS tags. An RCT, HP, or an authorized individual are responsible for the maintenance, creation, and removal of the tags.

An HPRMS tag contains the following information:

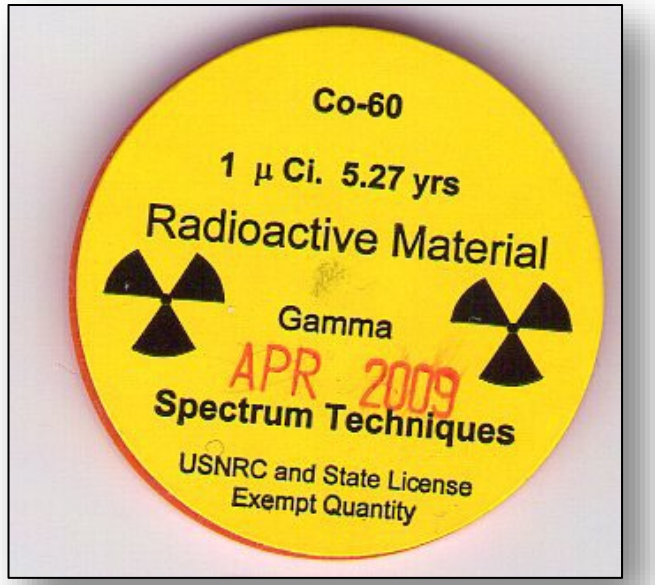
- Instruments used
- Location information
- Item description
- Radionuclides
- Contamination and Radiation survey information
- The responsible RCTs information and signature





EO 3.5

Examples of Radioactive Sealed Sources



EO 3.5

Control of Radioactive Sealed Sources

- Radioactive Sealed Sources are referred to as an RSS
- Contact the source custodian if you
  - plan to order a new sealed source
  - have questions about procedures for controlling sealed sources
  - discover that a sealed source is unaccounted for, missing, or not properly controlled
- The source custodian must immediately contact the line manager and the source control office if a source is lost

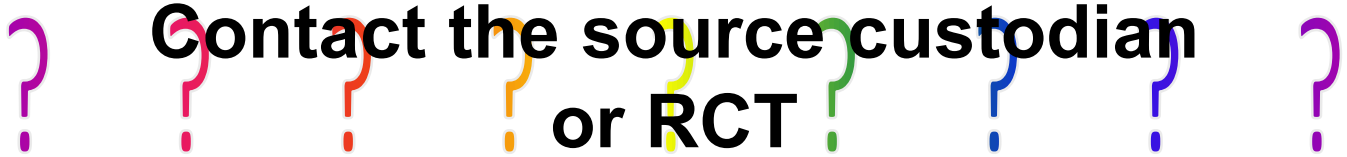
Control of Radiation Generating Devices

- Radiation Generating Devices are referred to as an RGD
- RGDs are devices such as X-ray scanners, X-ray diffraction instruments, particle accelerators, and electron microscopes.
- Contact the RGD owner/custodian if you
  - Plan to order a new RGD
  - Plan to move an RGD
  - Are making repairs to RGD
  - Have any questions about procedures for controlling RGDs

Control of Radioactive Material

You discover that radioactive material is missing or not properly controlled.

What do you do?



Contact the source custodian or RCT

It is important to keep track of radioactive material and radioactive sealed sources because of

- radiation safety
- public protection (people and environment)
- national security issues
  - preventing the spread of nuclear weapons
  - terrorism (dirty bombs)

Reducing Radioactive Waste

- Minimize radioactive waste
- Segregate or separate radioactive waste from nonradioactive waste
- Segregate compactible waste from noncompactible waste
- Minimize the amount of mixed waste generated
- Use good housekeeping techniques

EO 3.5

Removing Waste

- Waste removal from a Radiological Controlled Area (RCA) requires procedure approval by line or facility management
- Applies only to RCAs controlled for
  - surface contamination
  - volume contamination
- Segregation methods before leaving an RCA
  - acceptable knowledge
    - Origin, processes involved, storage, use of materials, segregation
  - Measurement of surface and/or volume contamination

Unit 4:
Radioactive Contamination Control

Objectives Unit 4

- EO 4.1. Define Fixed, removable, and airborne contamination
- EO 4.2. State the appropriate response to indicators of potential area and personnel contamination
- EO 4.3. Identify methods used to control radioactive contamination
- EO 4.4. Identity the methods used to detect radioactive contamination
- EO 4.5. Identify the normal methods used for decontamination
- EO 4.6. Identify the proper PPE and its uses in radiological areas

Review of Radiation & Contamination

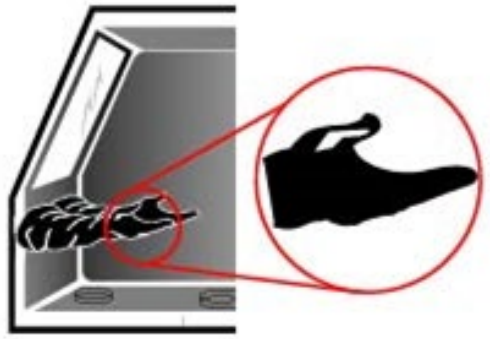
- Ionizing radiation: Energy emitted from radioactive atoms that can cause ionization
- Radioactive contamination: Radioactive material in an unwanted location

Types of Contamination

- Fixed contamination
  - cannot be readily removed from surfaces
- Removable contamination
  - can be readily removed from surfaces
- Airborne contamination
  - Contamination that is dispersed in the air as dust, particles, vapors or gases

Sources of Possible Contamination

Sharp objects in plastic bags containing radioactive material



Leaks in containment vessels

Leaks in radioactive systems

Grinding on radioactive material without proper controls

Indicators of Contamination and Response

- Leaks, spills, standing water
- Damaged radiological containers
- Increased count or alarm on personnel monitoring device
- Airborne contamination monitor alarm

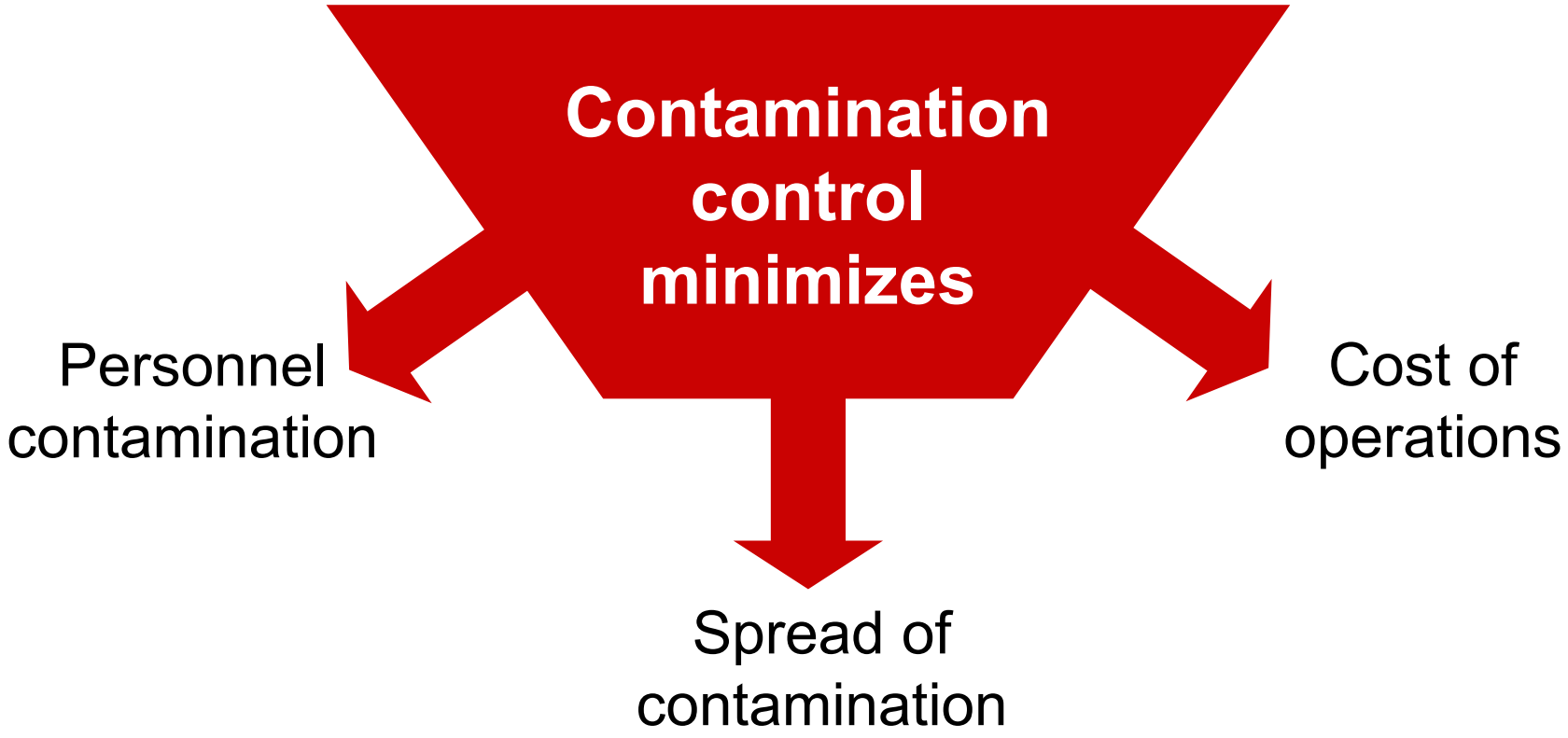
What do you do if you see a possible source of contamination?

1. STOP WORK!
2. Back away from the possible contamination
3. Warn others
4. Notify an RCT

Contamination Posting Levels (Removable)

Type of Contamination	Allowable Total Surface Contamination (dpm/100 cm^2)
Plutonium-238, plutonium-239 Other transuranics (heavier than uranium)	20
Natural thorium, thorium-232, strontium-90, iodine-131	200
Natural uranium, uranium-235, uranium-238 Associated decay products	1000
Cesium-137, cobalt-60 Other beta emitters	1000 (beta-gamma)
Tritium	10,000

Contamination Control



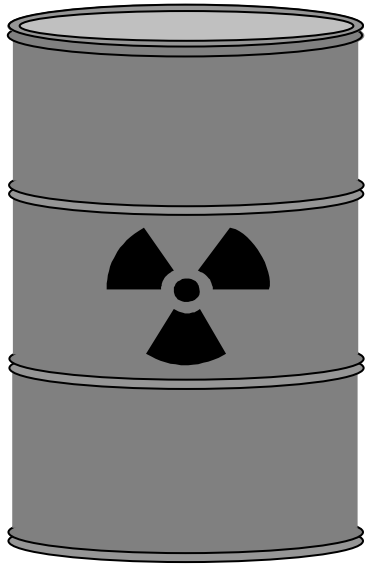
Contamination Control Methods

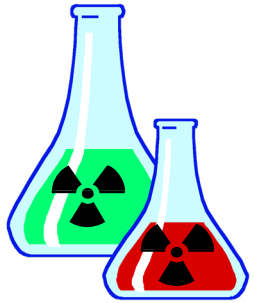
- Source reduction
- Engineering controls
- Administrative controls
- Proper radiological practices
- Personal protective equipment
- Decontamination

Proper controls help prevent the spread of contamination to other areas and can decrease personnel contamination.

Source Reduction

The removal of unneeded radioactive sources and material from your immediate work area

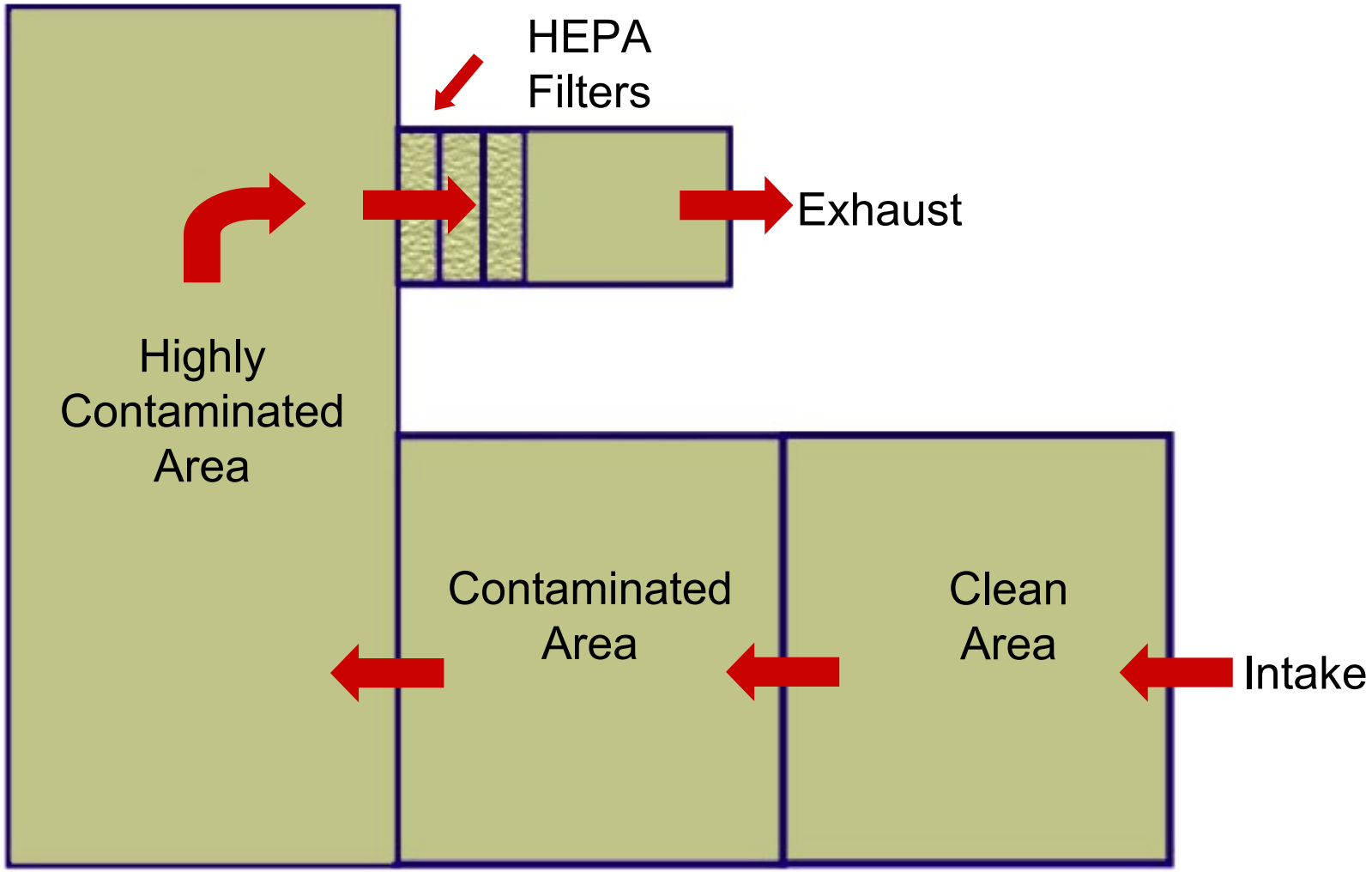




Engineered Control Methods

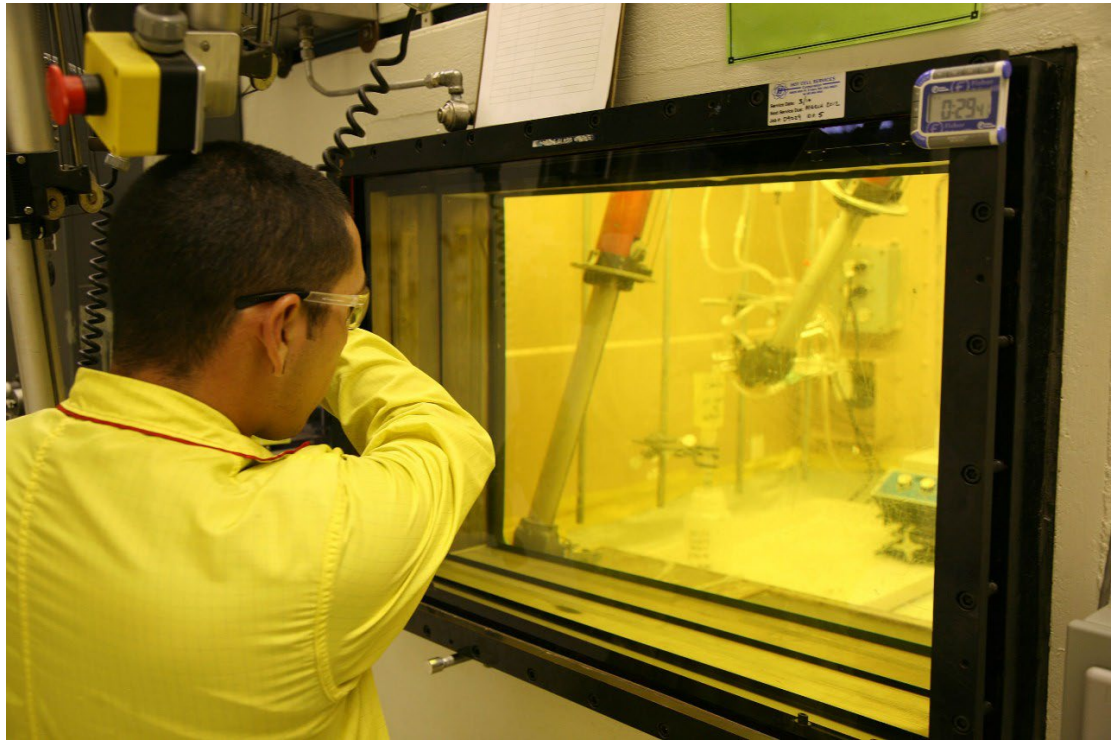
- Ventilation systems and local ventilation that keeps airflow
- HEPA filters that remove radioactive particles
- Easily decontaminated building and shielding materials
- Remote handling equipment
- Containment (ex. glove boxes)
- Traffic patterns established for movement of workers
- Physical barriers (ex. walls or doors)

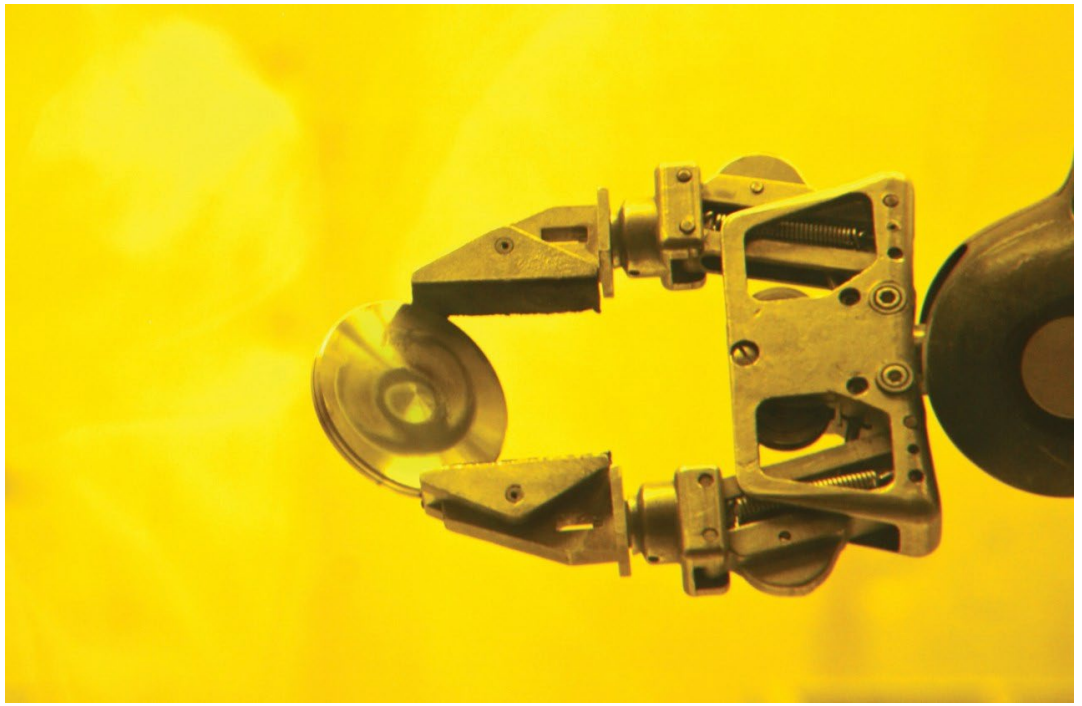
Engineering Control: Ventilation System



EO 4.3

Engineering Control: Remote Handler





Engineering Control: TA-53 Remote Handling Device

EO 4.3

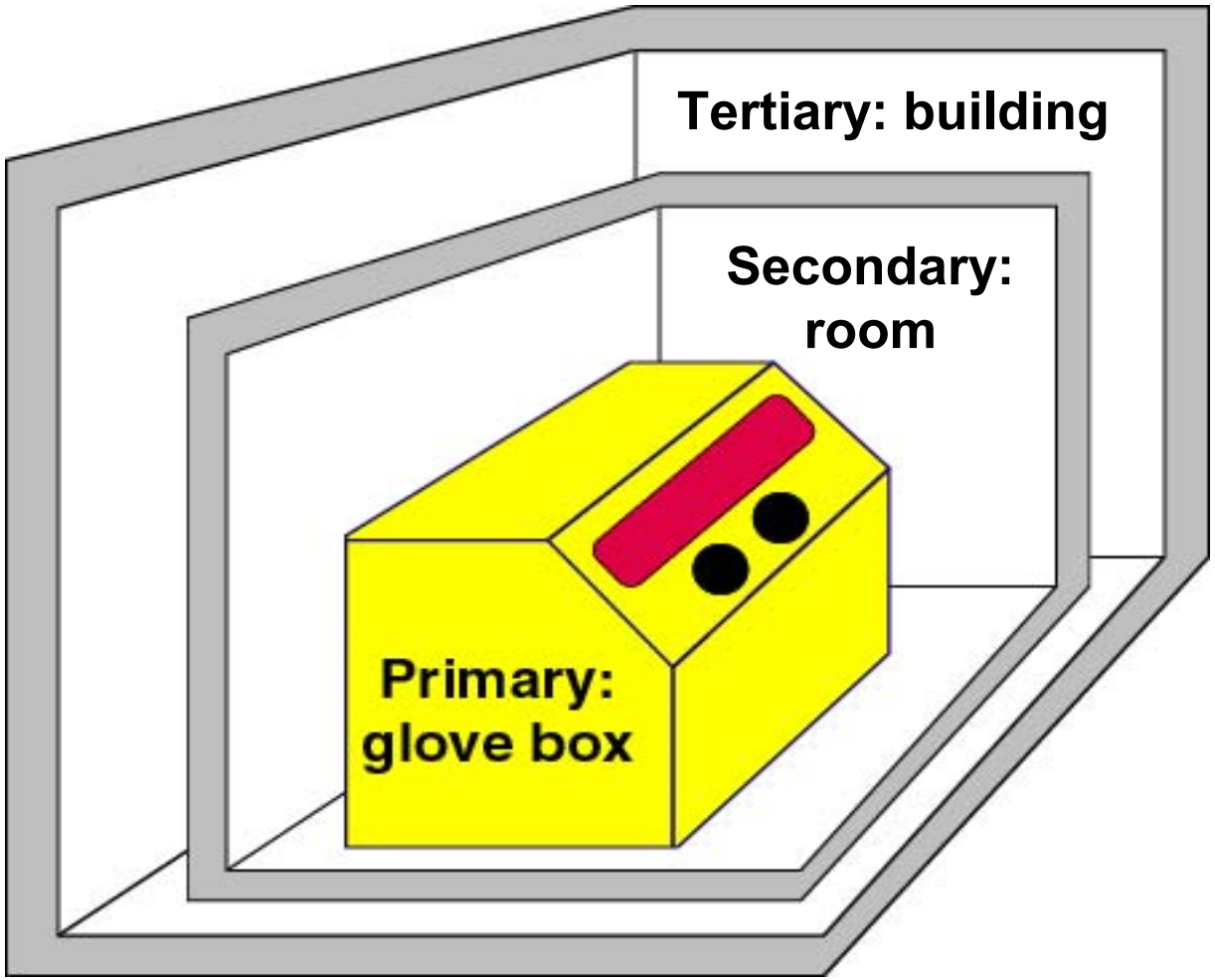
Engineering Control: Containment Tent

EO 4.3

Engineering Control: Containment & Fume Hood

EO 4.3

Engineering Control: Physical Barriers



EO 4.3

Administrative Control Methods

- Access restrictions
- Exit requirements
- Operating and maintenance procedures
- Technical work documents
- Radiological work permits
- Pre-job and post-job briefings

Proper Radiological Practices

Good Housekeeping

- Keep the work area clean
- Confine the spread of radioactive material
- Control and minimize movement of material
- Prevent spills
- Identify and report leaks
- Use preventive maintenance

Proper Radiological Practices (cont)

Good Work Practices

- Pre-stage work areas
- Comply with procedures and instructions
- Wear protective clothing and respiratory equipment as required
- Avoid contact with contaminated surfaces
- Change out protective equipment to prevent cross-contamination
- Do not eat, drink, smoke, chew, or apply cosmetics or lip balm in contaminated areas
- Use precautions when containing radioactive material in trash bags and containers
- Contact an RCT before opening shipped packages containing radioactive material

Self-Surveying for Contamination

When preforming a self-survey the following needs to be considered:

- Ensuring the detector works
- Maintain proper speed/distance
- Survey from most likely areas to least likely
- Respond properly to the detector output

Ensure the Detector Works

1. Check for physical damage
   - Mylar tears
   - Data cord connections/damage
2. Check the calibration date
3. Check for electrical power (battery/cord)
4. Response check the instrument

- In addition to function checking, response checking can remind you of the proper distance/speed
  - What happens if the source is too far away?
  - How far is too far away?
  - What happens if you move the source?
  - How fast is too fast?

Maintain Proper Speed/Distance

- The faster you go, the more you might miss
- 1-2 inches per second is best

- Distance is critical for alpha surveying
- Surfaces *must be* within ¼” of the detector for alpha and beta/gamma
- Better too close than too far away

Handheld Contamination Monitors

When looking for alpha contamination,

1. how far away should the probe be from the surface you are monitoring?
2. how fast should you move the probe?

- Alpha
  - Hold probe 1/4 inch or less from the surface
  - Move probe 1 to 2 inches per second

- Beta or gamma
  - Hold probe 1/4 inch or less from the surface
  - Move probe 1 to 2 inches per second

Survey from Most Likely to Least Likely

- Feet and hands are most likely to be contaminated
- If they are, the sooner you know it, the better, so start there
- As you work, remember what body parts have “touched down” so you can survey those
- Keep your speed/distance *constant* – do not do a great job on the first limb, and speed up for the rest

Respond Properly to Detector Output

- All detectors see some background (alphas see least, but not zero)
- Detectors can respond without setting off an alarm; this could indicate contamination
  - Is it reproducible? Could it be a random background event? Resurvey to find out!
  - If it is reproducible, stay put and call an RCT
- If the alarm goes off, that is not a background event – stay put and call the RCT

Decontamination

- The removal of radioactive material from locations where it is not wanted
- A means of reducing contamination within limits
- Decon is not always possible because of economic or radiological conditions

- Whom do you notify for all contamination events?

  - Notify an RCT of any and all contamination events

- Decontamination must be done under whose supervision?

  - Decon activities must be performed under RCT direction
  - Some decon events will require a Radiological Work Permit
  - Be aware of chemical cleaners, and avoid mixed waste
  - Follow RCT instructions

Personnel Decontamination

- Skin or clothing (under RCT supervision)
  - masking tape on clothing
  - lukewarm, mild soapy water on skin
  - if these decon methods do not work, you will be taken to OCCMED (Occupational Medicine) for other decon methods
- Internal (under medical supervision)
  - radioactive half-life
  - biological half-life (biological elimination)
  - intake of fluids and diuretics to flush contamination from your tissues
  - chelating or blocking agents are occasionally used (under medical supervision only)

PPE: Protective Clothing

- Anti-Cs required in contamination areas
- Degree of protection depends on conditions and job (Level I vs Level II)
- Deliberate decisions are required regarding what is worn under anti-C clothing:
  - Personal clothing or modesty garments may be worn under anti-C lab coats
  - Personal clothing is not worn under level I or II anti-Cs, with the exception of personal underwear and socks or as prescribed in an RWP or FRPR (or in training)
  - Lab-issued underwear is considered modesty garments

EO 4.6

Required PPE

Minimum PPE for Entry into Areas		
For entry into . . .	**and this situation . . .**	**this PPE is required.**
Radiological buffer area (RBA) controlled for contamination	Routine entry	Anticontamination (anti-C) lab coat and booties (including long pants and shoes that enclose the foot)
RCA controlled for contamination	Routine entry	Long pants and shoes that enclose the foot (not considered PPE, but required as a minimum)
Contamination Area or High Contamination Area	Light and moderate work	Level I clothing: one pair of coveralls, two pair of impermeable gloves (inner pair taped), one pair of booties, and optional skull cap or hood
Contamination Area or High Contamination Area	Heavy work	Level II clothing: two pair of coveralls, two pairs of impermeable gloves (inner pair taped), two pairs of booties, and optional skull cap or hood
Airborne Radioactivity Area	Any	Level I or Level II clothing with hood and required respiratory protection equipment

Minimum PPE for Selected Activities	
For this activity . . .	**this PPE is required.**
Routine work in or accessing containment or confinement systems with dispersible radioactive material (e.g., glove boxes, hoods); the established engineered controls are working	Anti-C lab coat, gloves, booties
Working with items with removable contamination in excess of the levels specified in P121 Table 14-2 (e.g., benchtop work with contaminated radioactive material or surfaces)	Anti-C lab coat, gloves, booties
Activities where the potential for personal contamination is limited to the hands, arms, and upper front portion of the body	Anti-C lab coat, gloves,
Handling large quantities of contaminated liquids where immersion is possible	Level I with water-resistant or impermeable outer layer
Penetrating or otherwise challenging contaminated systems (e.g., glove boxes, hoods, ventilation systems, pumps); the established engineered controls are breached; this is not considered routine work	Level I or II, dependent on potential hazard; additional SME review and approval required for each evolution
Responding to releases of radioactive material (mitigation, characterization, recovery)	Case dependent; use conservative PPE under the direction of appropriate SME or follow emergency response procedures
Other activities with the potential for personnel contamination	Case dependent; follow posting, work control documents, and SME instructions

Proper Use of Protective Clothing

- Inspect PPE for holes
- Do not wear personal effects (jewelry, watch) that you do not want to lose because of contamination
- Proceed directly to the work area
- Contact an RCT if clothing becomes torn
- Do not
  - touch uncovered parts of the body
  - wear anti-Cs outside designated areas
  - get anti-Cs wet

EO 4.6

PPE Examples

Example of level I PPE and Lab Coat and Booties

- When is a level I PPE worn vs Lab Coat and Booties?

Example of level II PPE

- When is a level II PPE worn?

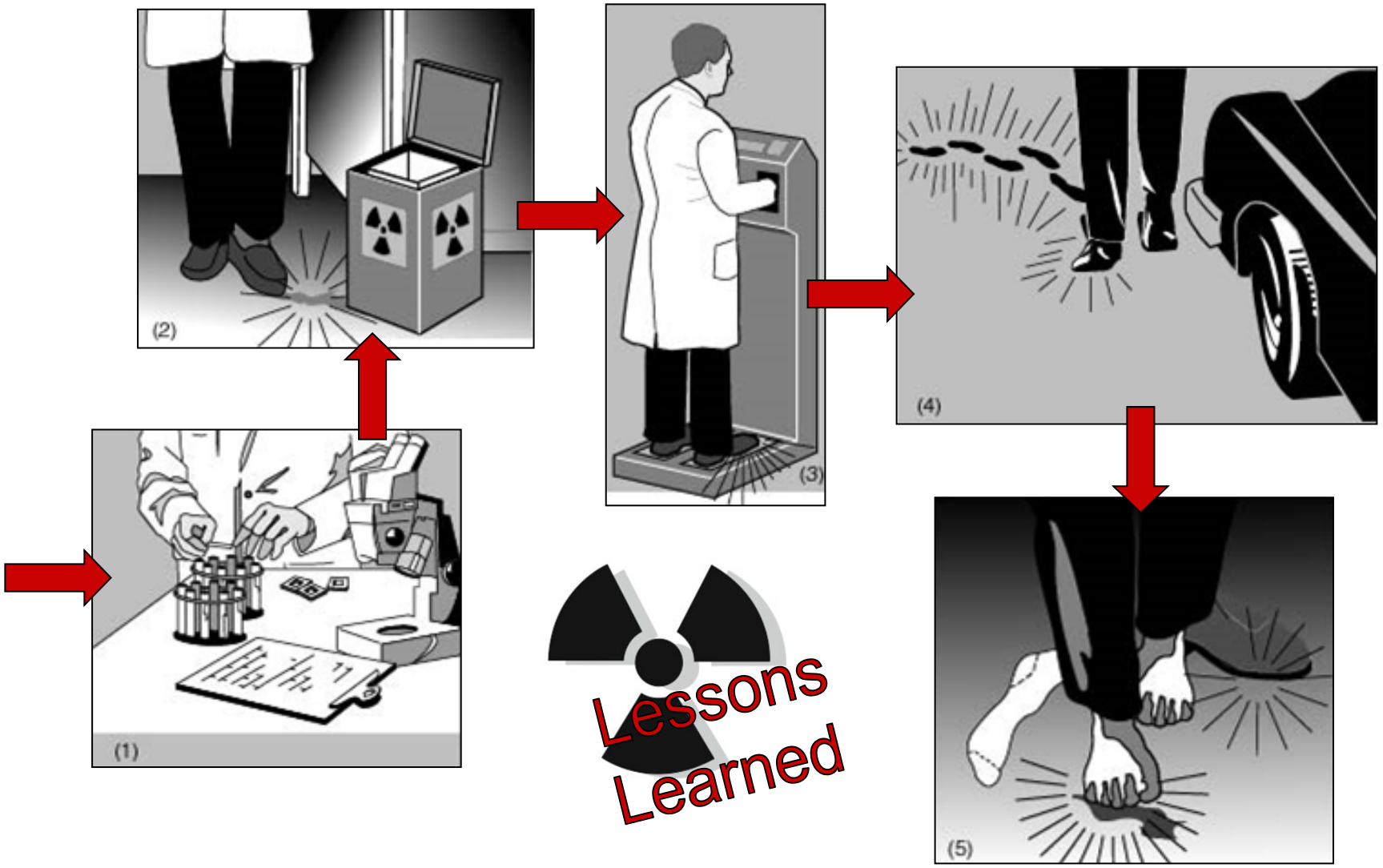
EO 4.6

PPE: Respiratory Protective Equipment

- Used to prevent the inhalation of radioactive material
- Requires worker qualification for use

Note: This course <u>does</u> <u>not</u> qualify a worker to wear respiratory equipment.

Contamination Occurrence



Unit 5:
Personnel Monitoring Programs & Dosimetry

Objectives Unit 5

- EO 5.1. State the purpose and requirements for personnel monitoring
- EO 5.2. Describe the types of personnel monitoring methods
- EO 5.3. Identify the worker responsibilities for participation in personnel monitoring programs
- EO 5.4. Identify how to obtain radiation dose and annual dose summary
- EO 5.5. Explain the worker responsibilities for monitoring exposure
- EO 5.6. Explain the Consequences of failure to comply with radiological requirements
- EO 5.7. Describe dose recording methods and reporting requirements
- EO 5.8. Describe reporting procedures for radiation dose received from medical or other employment

Dosimetry and Health Physics Checklist

- All radiological workers are required to enroll in dosimetry
- A health physics checklist is used to assign individuals to the appropriate monitoring program
- Completed when a supervisor requests permanent dosimetry for an individual
- A new form is completed if a change in job assignment may affect monitoring requirements

Types of External Dosimeters

The following are the dosimeters most commonly used at LANL:

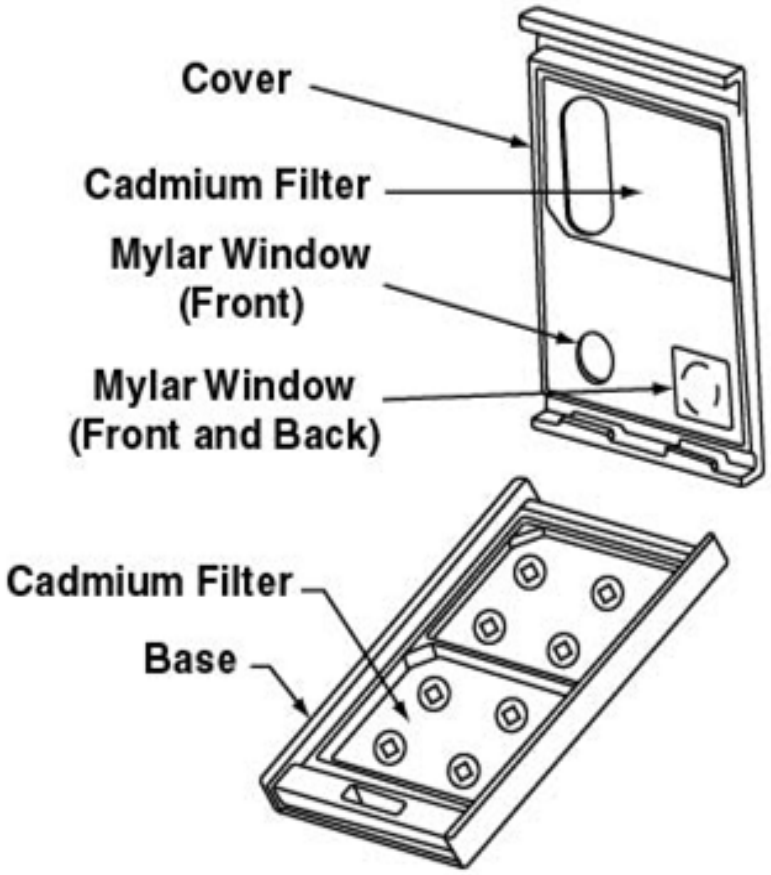
- Thermoluminescent dosimeter (TLD)
- Wrist dosimeter
- Track-etch dosimeter (Blueberry)
- Nuclear accident dosimeter
- Electronic pocket dosimeter (EPD)

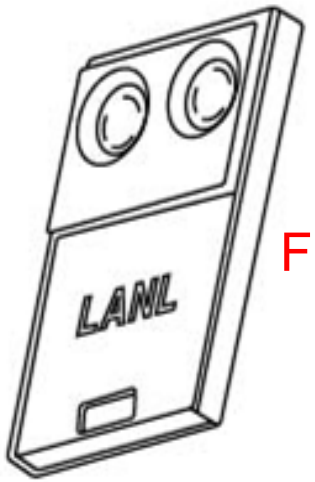
Thermoluminescent Dosimeter (TLD)

- Used to assess the legal dose of record
- Assesses high-energy beta, gamma, x-ray, and neutron radiation dose
- Issued by RP through group offices
- Processed monthly, quarterly, or as needed

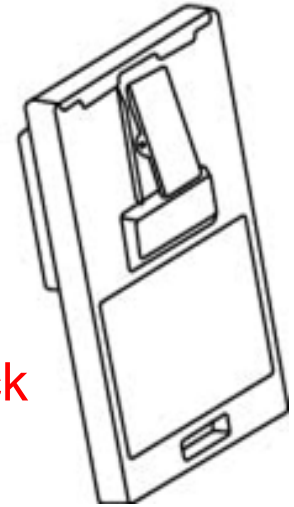
EO 5.2

Thermoluminescent Dosimeter (TLD)





Front



Back

EO 5.2

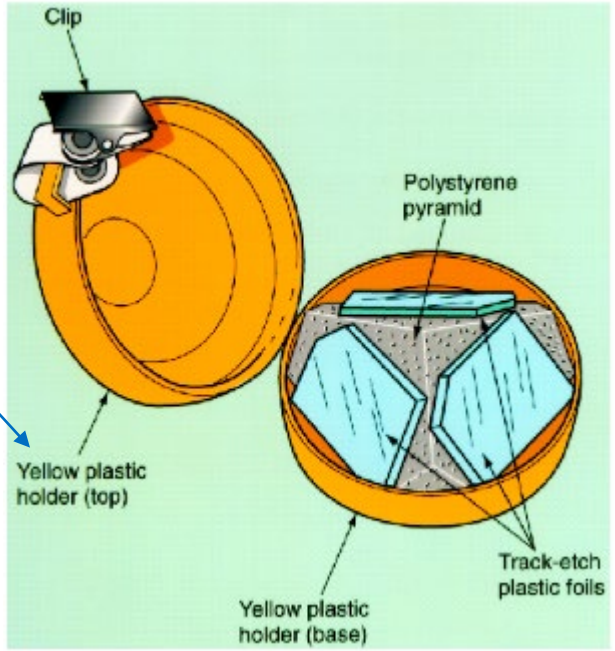
Wrist Dosimeter

- Contains a TLD chip
- Measures high-energy beta, gamma, and x-ray radiation dose to extremities
- Measures exposure to the extremities
- Issued by RP through the RCTs
- Processed monthly or at the end of the job

Track-Etch Dosimeter

- Commonly referred to as a “Blueberry”
- Assesses dose from neutron radiation at energies greater than 5 MeV
- Issued by RP through RCTs at certain technical areas
- Processed quarterly or as needed

Note: Track-etch dosimeters are now blue in the field



Electronic Pocket Dosimeter (EPD)

- Measures Gamma rays and X-rays dose
- Issued by RP through the RCTs for certain jobs
- Digital display
- Alarm can be set to warn when a specified level or dose rate is reached

Personal Nuclear Accident Dosimeter (PNAD)

- used at locations where the possibility of a criticality accident exists
- Used to measure high-level neutron radiation dose over the whole energy range
- Issued by RP through the RCTs at certain technical areas
- Processed as needed

EO 5.2

Correct Use of Dosimeters

- Wear at all times in designated areas
- Wear TLD on the chest between the neck and the waist (declared pregnant worker wears dosimeter between neck and waist)
- Wear supplemental dosimeters within 3 inches of primary dosimeters
- Keep clean, closed, and free from contamination
- Return for processing as required
- Follow facility-specific storage procedures

DO NOT . . .

- Leave in the car on the dashboard or in direct sunlight
- Expose to non-work-related sources of radiation
- Take on travel or wear at any other location without permission from RP-PROG

Damaged, Off-Scale, or Contaminated Dosimeters

If your dosimeter is damaged or off-scale or if it alarms or becomes contaminated,

1. stop work
2. place work in a safe condition
3. alert others
4. exit the area
5. notify an RCT

Lost Dosimeters

- If your TLD is lost, contact an RCT
- Line manager completes and submits a report to RP-PROG
- If your lost TLD is found later, RP-PROG determines whether the lost or replacement TLD should be worn
- A temporary TLD can be provided if you leave your TLD at home. This does however cause a report of this to made

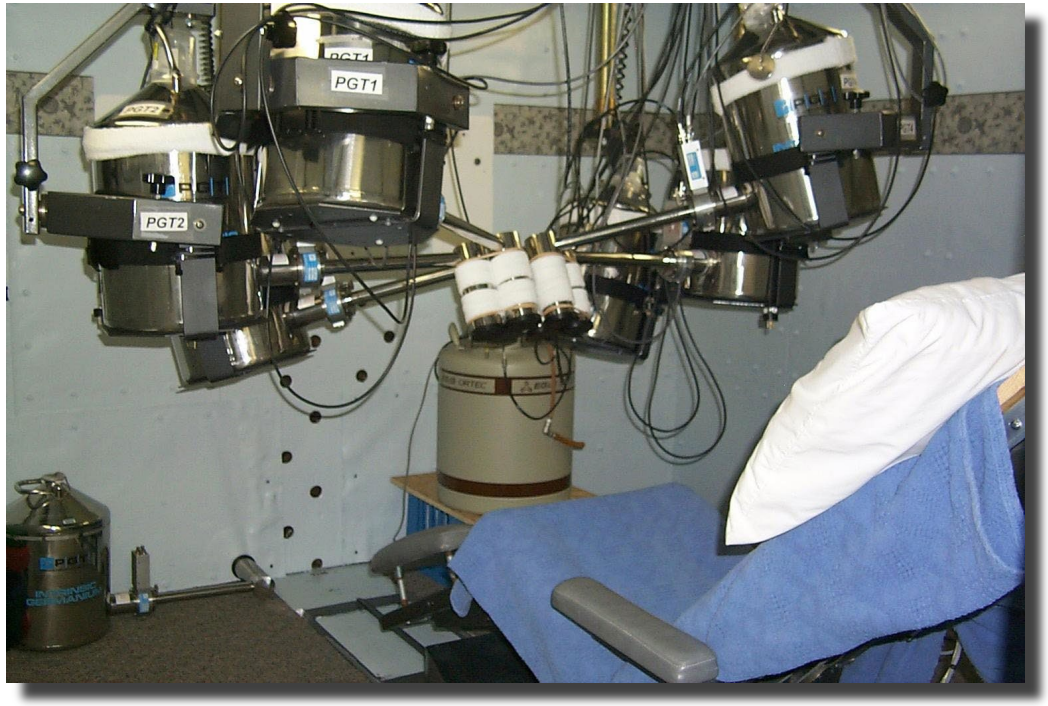
Internal Dosimetry Methods

- In vivo monitoring (direct bioassay)
  - Direct measurement from outside the body

- In vitro monitoring (indirect bioassay)
  - Analysis of bodily fluid or material

In Vivo Monitoring

- Measures amount of internally deposited radioactive material by direct measurement from outside the body
- Examples include
  - Whole-body counting
  - chest counting
  - thyroid counting
  - wound counting



In Vivo Monitoring

- Used to measure fission and activation products

In Vitro Monitoring

- Measures internally deposited radioactive material by analysis of bodily fluid or material
- Examples include
  - urine sampling
  - fecal matter sampling
  - blood sampling
  - saliva sampling
  - nasal swiping
  - wound tissue sampling

Your Internal Dosimetry Responsibilities

- Have whole-body counts as follows:
  - baseline
  - whenever instructed
  - termination of employment

- Submit in vitro samples as follows:
  - baseline
  - as required by program
  - termination of employment

EO 5.3, 5.5

Monitoring Pregnant Workers

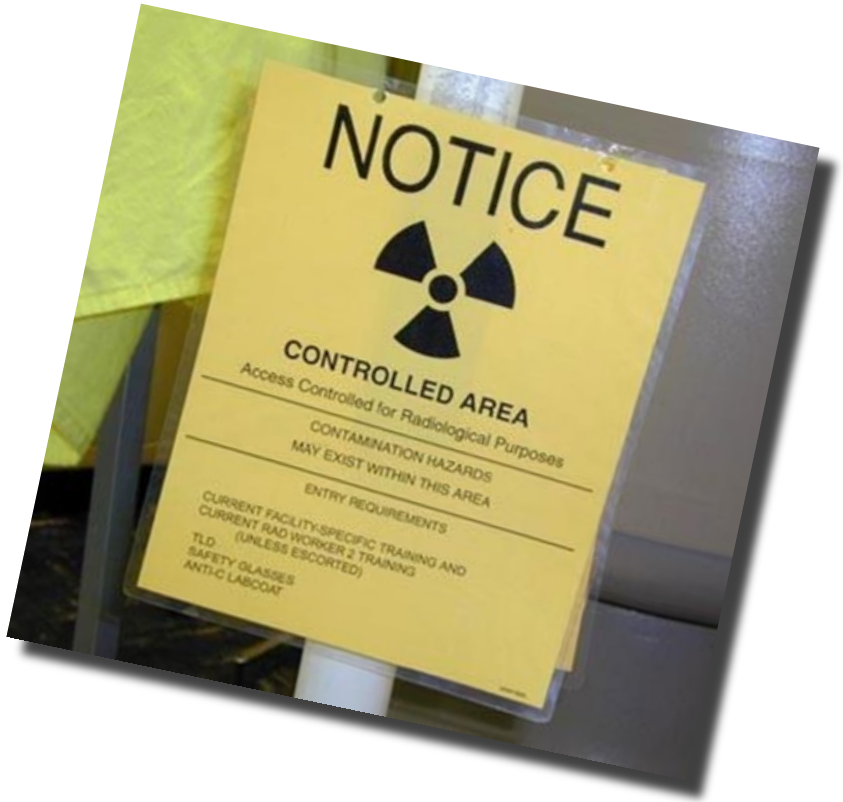
- A radiological worker who is pregnant is encouraged to notify OCCMED (Occupational Medicine) in writing
- The RHAP (Reproductive Health Assistance Program) will evaluate your work situation

Radiation Dose Reporting and Records

- Workers must report to the Dose Assessment Team, Health Physics Measurements, RP
  - doses received at other sites
  - medical radiological procedures to your RCT
- Report medical radiological procedures to your group leader or supervisor as far in advance as possible
- RP maintains records and provides
  - monthly records to line organizations
  - annual records to individual workers
  - termination records within 90 days
  - visitor records within 30 days

EO 5.4, 5.7, 5.8

Unit 6:
Radiological Access Controls and Postings



Objectives Unit 6

- EO 6.1. Describe the minimum appearance requirements for radiological postings and signs.
- EO 6.2. State the purpose of and information found in radiological postings, signs, and labels, including the types of areas controlled for radiological purposes.
- EO 6.3. Describe the consequences of not complying with radiological direction, postings, or labels.
- EO 6.4. State the purpose of and information found on radiological work permits or other applicable forms of work authorization documents.
- EO 6.5. Describe the worker's responsibilities for complying with radiological worker permit (RWP); access control system or process; and radiological postings, signs, and labels.

Posting Colors and Symbol

- Black or magenta lettering and trefoil on a yellow background
- Magenta and yellow barriers, ropes, tape, and chains
- Must be clearly visible from all directions
- **You must stop at ALL Barriers, ropes, tape and, chains**
- It is dangerous to disregard these notices and postings

Posting Information

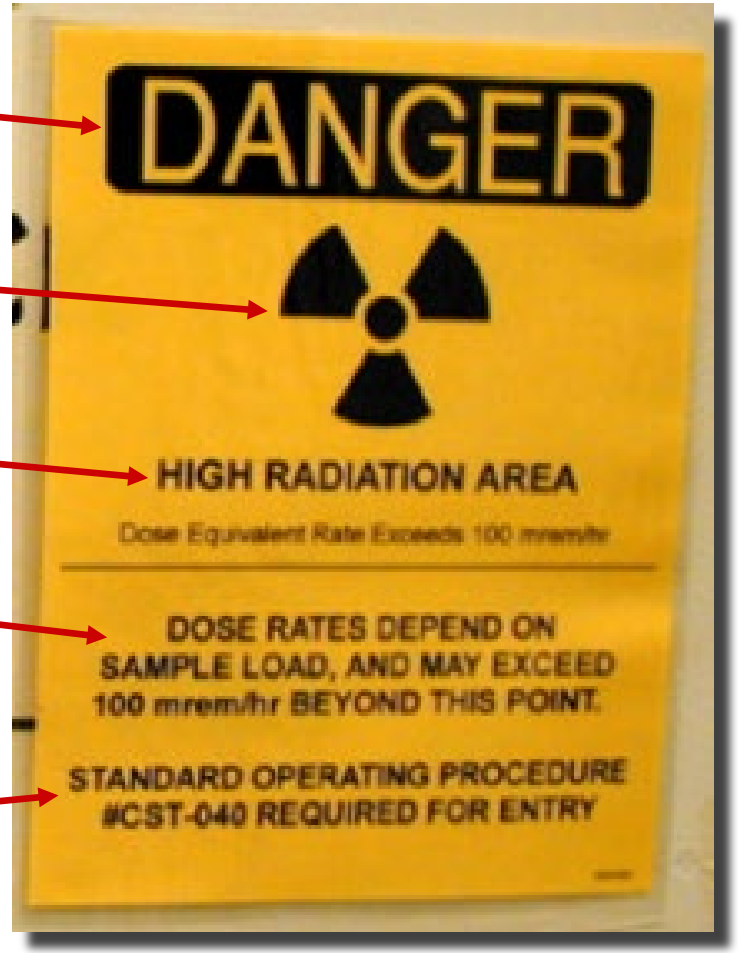
Level of hazard

Trefoil symbol

Area designation

Specific radiation dose or contamination level

Normal entry requirements



EO 6.1, 6.2

Level of Hazard

The word(s) . . .	is like . . .	and means . . .	You should . . .
NOTICE	the road sign “traffic signal ahead”	hazards may exist.	proceed.
CAUTION	a flashing-yellow traffic light	hazards do exist.	proceed with caution, accompanied by an RCT or other appropriate personnel.
DANGER	a flashing-red traffic light	significant dangers do exist.	pause to evaluate the danger, with the help of an RCT or other appropriate personnel.
GRAVE DANGER	a red light	a very great danger exists.	STOP. Do not proceed until the conditions have been evaluated by an RCT and a senior manager. Only volunteers who are fully aware of the risks may proceed.

Types of Radiological Areas

The three primary types of radiological areas found at LANL are

- radiation areas
- contamination areas
- airborne radioactivity areas

The words “high” or “very high” may also appear on the radiological posting. For example, you may encounter postings containing the wording “CAUTION: Radiation Area” or “Grave Danger: Very High Radiation Area.”

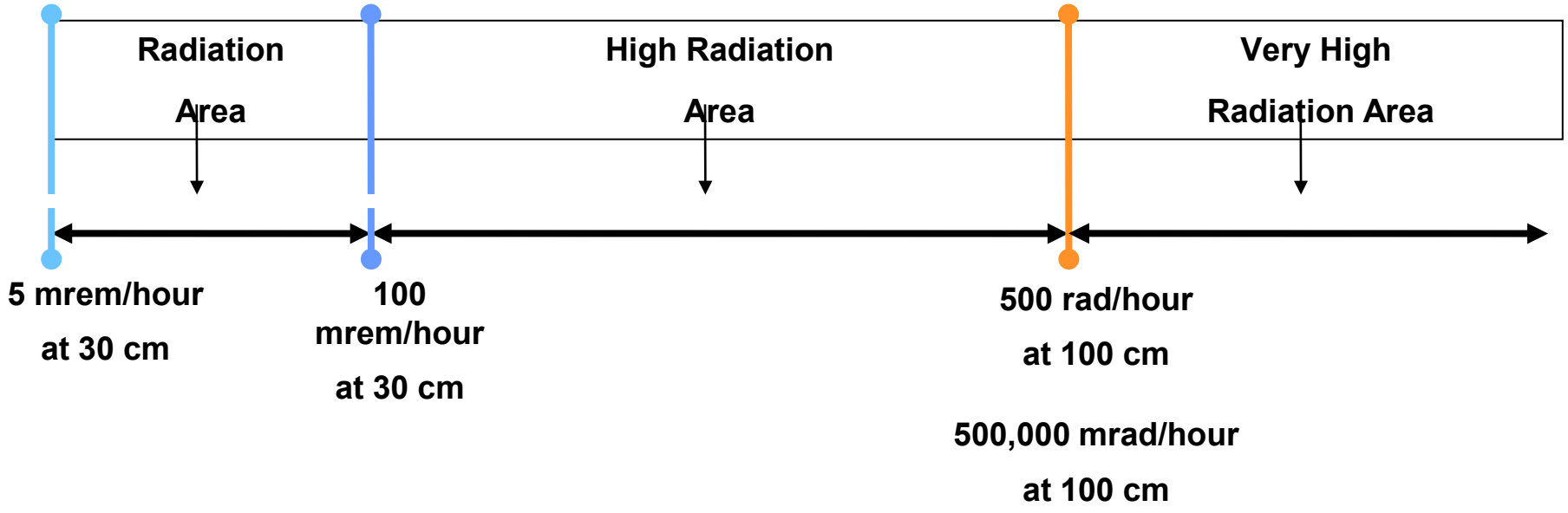
Criteria for a Radiological Postings - Radiation

Posting	Defining Conditions	Minimum Entry Requirements	Exit Requirements
Controlled Area	Not expected to receive a dose exceeding 100 mrem/yr; contamination unlikely.	General Employee Radiological Training (GERT), facility-specific training If RCA is controlled for contamination: • Long pants	RCAs controlled for external radiation: • None RCAs controlled for contamination: • Hand and foot frisk • Monitor other areas of the body suspected of contamination
Radiological Buffer Area	Where individuals are expected to receive >100 mrem/yr or potential contamination levels greater than Table 14-2 of P121 values. May be used for areas containing hoods, glove boxes, and rooms with radiation-producing machines.	Radiological Worker II Training Live, Course 20301, and facility-specific training RBAs controlled for external radiation: • TLD RBAs controlled for contamination: • Anti-C labcoat • Booties • Long pants • Shoes that enclose the foot	RCAs controlled for external radiation: • None RCAs controlled for contamination: • Hand and foot frisk • Monitor other areas of the body suspected of contamination
Radiation Area	>5 mrem/hour at 30 cm from source ;up to 100 mrem/hour	Radiological Worker II Training Live, Course 20301, and facility-specific training • TLD • FRPR (facility radiation protection requirement) or RWP	None
High Radiation Area	>100 mrem/hour at 30 cm from source; up to 1 rem/hour at 30 cm from source	Radiological Worker II Training Live, Course 20301, and facility-specific training • TLD • Supplemental Dosimeter • FRPR or RWP	None
Very High Radiation Area	>500 rad/hour at 100 cm from source	Training to be determined and approved by the RP division leader	None

EO 6.2

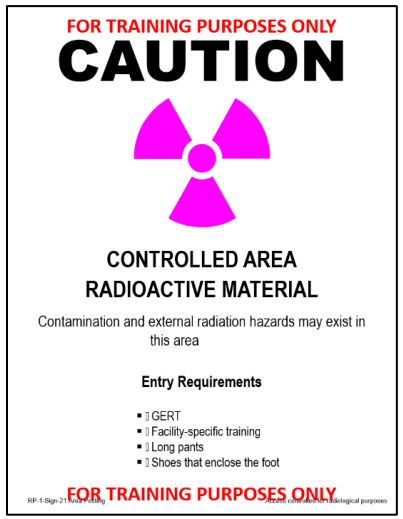
Criteria for a Radiological Posting con.

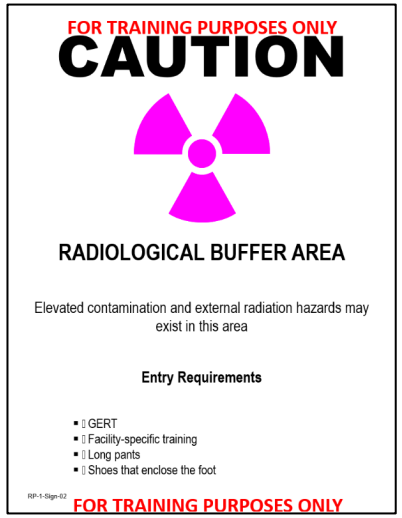
Posting	Defining Conditions	Minimum Entry Requirements	Exit Requirements
Hot Spot	Contact reading of at least 100 mrem/hr and have a contact reading greater than 5 times the 30cm reading	N/A	N/A
Radioactive Material	Accessible areas where items or containers of radioactive material in quantities greater than Appendix 16A values (P121-1.0) are used, handled, and stored	GERT, facility-specific training	N/A
Hot Job Exclusion Area	As posted	Consistent with area conditions RWP required for planned radiological work	Consistent with area conditions

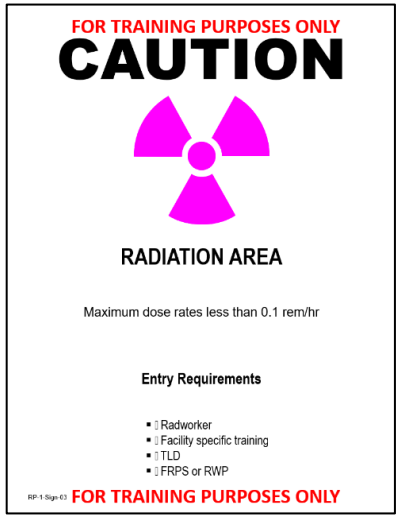


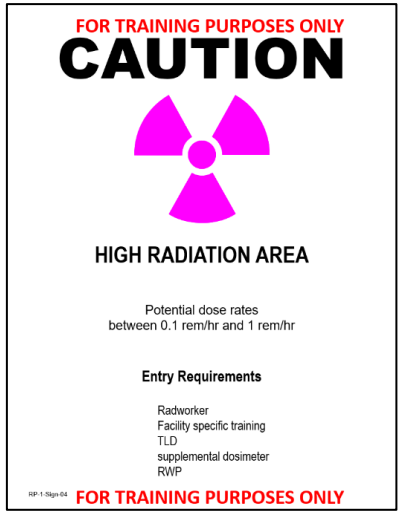
EO 6.2

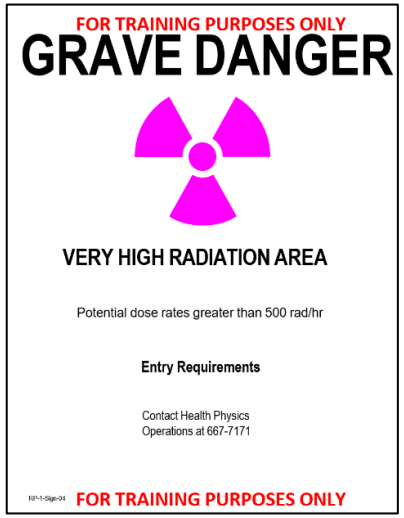
Radiation Area Postings

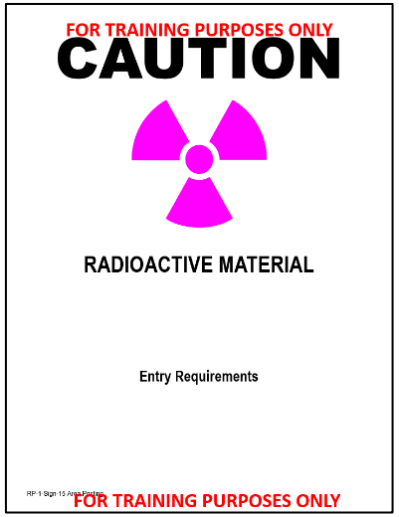


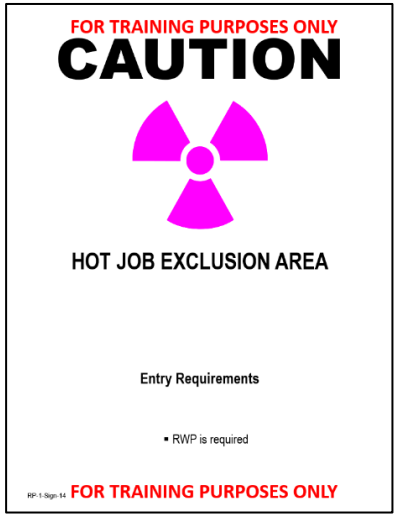










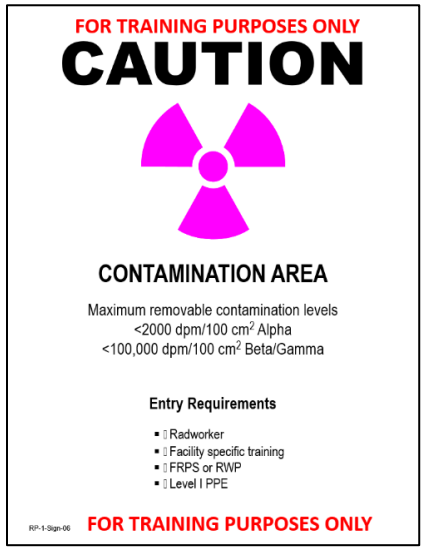


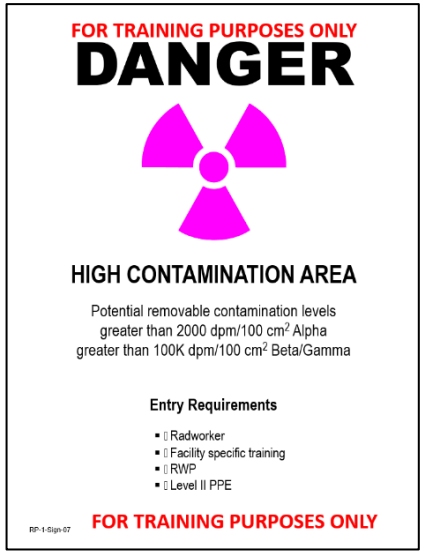
NOTE: In the field these signs will have a yellow background

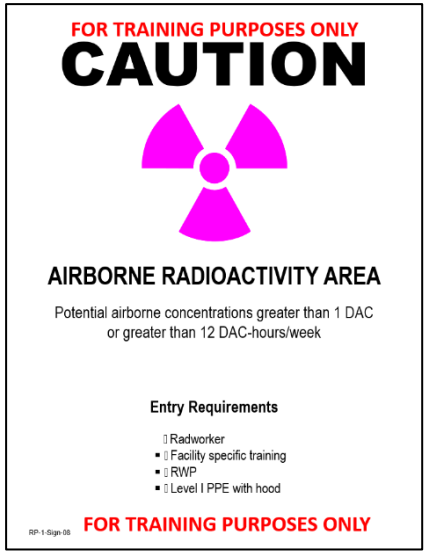
Criteria for a Radiological Posting- Contamination

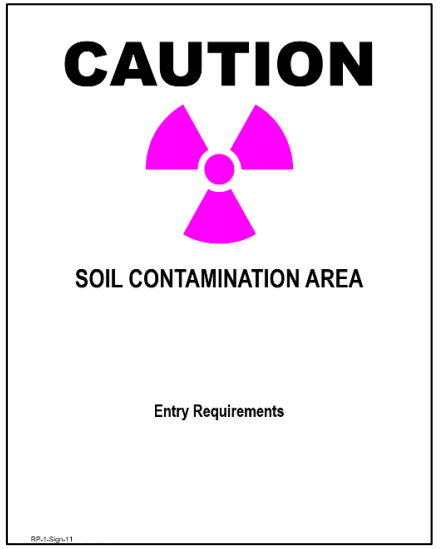
Posting	Defining Conditions	Minimum Entry Requirements	Exit Requirements
Contamination Area	Levels (dpm/100 cm^2) that are greater than (or likely to exceed) Table 14-2 values but do not exceed 100 x Table 14-2 values (ISD 121-1.0).	Radiological Worker II, TLD, anti-Cs, and authorization by way of work control documents as required and appropriate internal dosimetry programs.	Exit only at step-off pad(s). Remove anti-Cs carefully.
High Contamination Area	Levels (dpm/100 cm^2) that are greater than (or likely to exceed) 100 x Table 14-2 values (ISD 121-1.0).	Radiological Worker II, TLD, anti-Cs, RWP, and authorization by way of work control documents as required and appropriate internal dosimetry programs. Read and sign that you understand the job, radiological conditions, and protection requirements as written in the RWP and will abide by them.	Monitor personnel via a whole body frisk. Monitor personal items and equipment.
Airborne Radioactivity Area	Concentrations ($\mu Ci/cm^3$) above backgrounds that are greater than the derived air concentration (DAC) values or that would result in an individual's being exposed to greater than 12 DAC-hours in a week, without respiratory protection..	Radiological Worker II, TLD, anti-Cs, RWP, respirator, and authorization by way of work control documents as required and appropriate internal dosimetry programs.	
Soil Contamination Area	Contaminated soil not releasable in accordance with DOE Order 5400.5.	Radiological Worker II, facility/ job-specific requirements.	Facility/job-specific requirements may apply.
Fixed Contamination	No removable contamination and total contamination levels that are greater than Table 14-2 values (ISD 121-1.0).	N/A	N/A

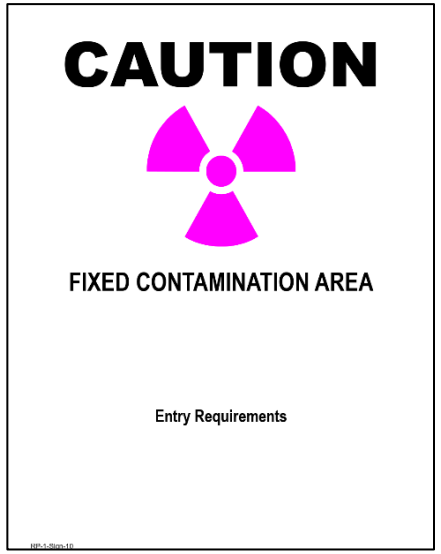
Contamination Area Postings











NOTE: In the field these signs will have a yellow background

EO 6.2

Your Responsibilities

Before entering an area, read any:

- postings
- signs
- labels

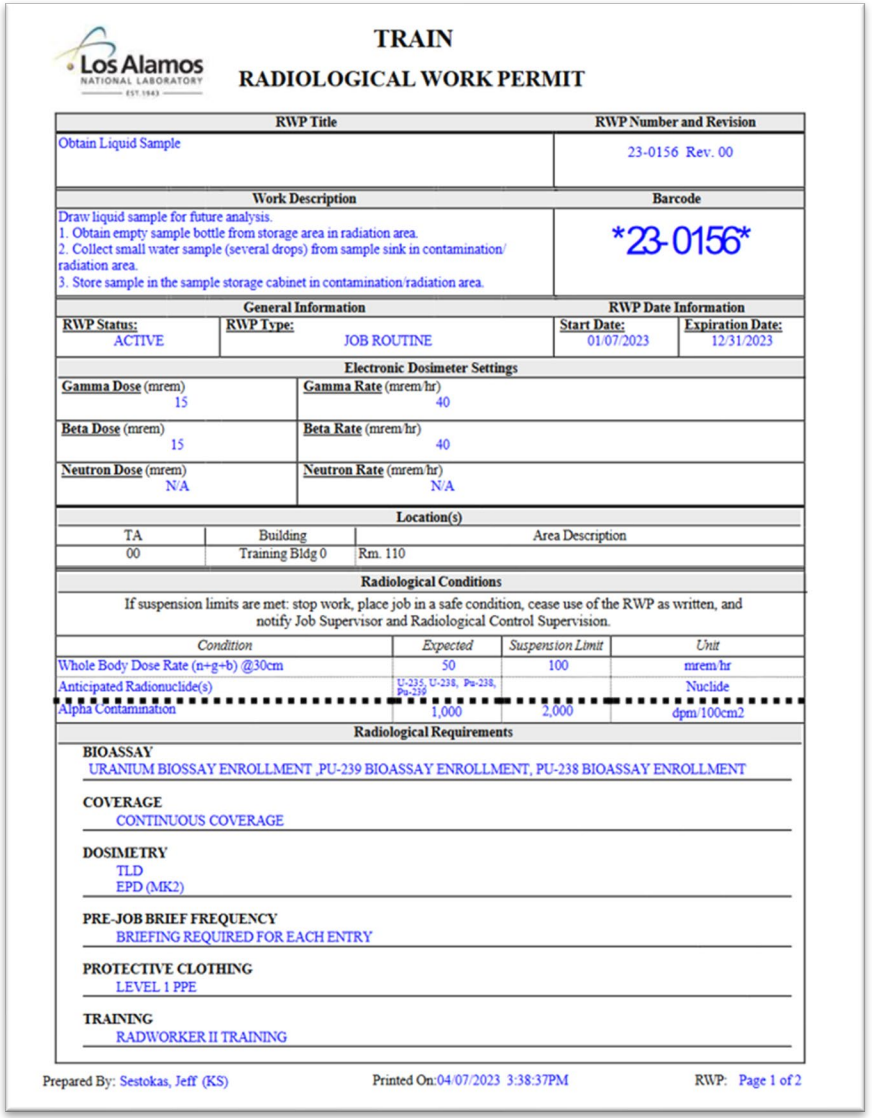
Disregarding or removing postings, signs, or labels could lead to:

- unnecessary or excessive personnel radiation exposure
- personnel contamination
- release of contamination to the environment or public
- disciplinary action

Purpose of Radiological Work Permits

- To inform workers of potential radiological conditions, safety hazards, and other concerns
- To inform workers of radiological controls
- To relate radiation doses from specific jobs to work performed
- To serve as a legal document of record

Note: RWPs require other safety-related documents



Los Alamos NATIONAL LABORATORY EST. 1943

TRAIN

RADIOLOGICAL WORK PERMIT

RWP Title	RWP Number and Revision
Obtain Liquid Sample	23-0156 Rev. 00

Work Description	Barcode
Draw liquid sample for future analysis. 1. Obtain empty sample bottle from storage area in radiation area. 2. Collect small water sample (several drops) from sample sink in contamination/ radiation area. 3. Store sample in the sample storage cabinet in contamination/radiation area.	*23-0156*

General Information		RWP Date Information	
RWP Status: ACTIVE	RWP Type: JOB ROUTINE	Start Date: 01/07/2023	Expiration Date: 12/31/2023

Electronic Dosimeter Settings

Gamma Dose (mrem) 15	Gamma Rate (mrem/hr) 40
Beta Dose (mrem) 15	Beta Rate (mrem/hr) 40
Neutron Dose (mrem) N/A	Neutron Rate (mrem/hr) N/A

Location(s)

TA	Building	Area Description
00	Training Bldg 0	Rm. 110

Radiological Conditions

If suspension limits are met: stop work, place job in a safe condition, cease use of the RWP as written, and notify Job Supervisor and Radiological Control Supervision.

Condition	Expected	Suspension Limit	Unit
Whole Body Dose Rate (n+g+b) @30cm	50	100	mrem/hr
Anticipated Radionuclide(s)	U-235, U-238, Pu-238, Pu-239		Nuclide
Alpha Contamination	1,000	2,000	dpm/100cm2

Radiological Requirements

BIOASSAY
URANIUM BIOSSAY ENROLLMENT ,PU-239 BIOASSAY ENROLLMENT, PU-238 BIOASSAY ENROLLMENT

COVERAGE
CONTINUOUS COVERAGE

DOSIMETRY
TLD
EPD (MK2)

PRE-JOB BRIEF FREQUENCY
BRIEFING REQUIRED FOR EACH ENTRY

PROTECTIVE CLOTHING
LEVEL 1 PPE

TRAINING
RADWORKER II TRAINING

Prepared By: Sestokas, Jeff (KS) Printed On:04/07/2023 3:38:37PM RWP: Page 1 of 2

EO 6.4

Types of RWPs

Two types of RWPs are used, depending on the radiological conditions **Routine** and **Specific**:

- A Job Routine RWP is used to control routine or repetitive activities, such as tours and inspections, in areas with historically stable radiological conditions. It is valid only for up to one calendar year (with 3-month reviews).

- A Job Specific RWP is used to control non-routine operations or work in areas with changing radiological conditions. It is valid only for the duration of a particular job (subject to 3-month reviews, should the job last that long).

In both cases RWPs are only valid for the calendar year they are written.

Information Found on RWPs

- General work information by stage
  (not a detailed step-by-step set of instructions)
- Radiological training requirements
- Pre-job radiological conditions and controls for each stage
- ALARA and radiological protection requirements
- Hold points and special instructions
- Required bioassay
- Approval signatures

Your RWP Responsibilities

- Read the RWP
- Understand conditions and protections on the RWP
- Attend the pre-job briefing
- Sign the pre-job briefing log to show you understand the RWP
- Obey the instructions on the RWP

What should you do . . .

- if you do not think the RWP is correct?
- if you do not think the RWP is completely filled in?
- if you do not understand any part of the information?

Do not start the job!
Contact an RCT or your supervisor

EO 6.5

Escorting Responsibilities

If you are required to perform escort duties, you must ensure that:

- you receive required training for escorting

- the person being escorted complies with the radiation protection plan and has received training related to the
  - risks of exposure to radiation and radioactive material
  - risks of prenatal radiation exposure
  - methods for requesting individual exposure records

Unit 7:
Radiological Emergencies

Objectives Unit 7

- EO 7.1. Explain the use of occupational monitoring systems as they relate to unanticipated radiological conditions.
- EO 7.2. Describe the appropriate response to unanticipated radiological conditions.
- EO 7.3. Explain the consequences and risks of disregarding alarms
- EO 7.4. Describe the appropriate responses to injuries
- EO 7.5. Describe how to respond to accidental breaches, leaks or spills in the workplace
- EO 7.6. Explain the consideration that are made during emergency situations

Emergency Alarms and Responses

At LANL, radiological emergency alarms and responses to them are facility specific:

- Alarms may sound different in different facilities
- Some facilities will require you to take and pass site-specific alarm training

Regardless of the sound of an alarm, you must know the appropriate responses to them. If an alarm sounds you must react.

EO 7.1, 7.2

Types of Radiological Alarms

- area radiation monitor (ARM)
- continuous air monitor (CAM)
- personnel contamination monitor (PCM)

Area Radiation Monitor (ARM)

- Measures radiation exposure level (Gamma)
- Used in locations with the potential for unexpected increases in radiation levels

Response to ARM Alarm

When you hear an ARM alarm, what actions do you take?

- Leave the area immediately, do not worry about clean up or shutting things down
- Report to a safe area
- Contact an RCT
- You may need to alert others in the area as you leave

Continuous Air Monitor (CAM)

- Measures airborne radioactivity levels
- Used in locations with the potential for unexpected increases in airborne radioactivity

Continuous air monitor

Response to CAM Alarm

If you ***are not*** wearing a respirator and a CAM alarm sounds,

- Leave the area immediately, alerting others as you leave
- Report to a safe area
- Notify an RCT
- Stand by outside the area while the RCT conducts a survey

If you ***are*** wearing a respirator and a CAM alarm sounds, what actions do you take?

- Stop operation safely
- Follow RCT instructions
- Do not remove respirator until surveyed by an RCT, unless needed for medical condition

Personnel Contamination Monitor (PCM)

EO 7.1

Personnel Contamination Monitor (PCM)

When you are self-monitoring for contamination and the PCM you are using alarms, what actions do you take?

- Remain in the immediate area
- Notify an RCT
- Minimize movement and potential for cross-contamination
- Tell the RCT where you have been and what you have touched

When you are self-monitoring for contamination using a PCM and you get an increased count but no alarm, what actions do you take?

- Reset the instrument
- Recheck that area carefully

If you get an increased count rate the second time, treat the situation the same as a PCM alarm and contact an RCT.

Situations Requiring Immediate Exit

- ARM alarm
- CAM alarm (unless wearing a respirator)
- Criticality alarm
- Evacuation alarm
- Stop work and evacuation order
- Lost or damaged dosimeter
- Off-scale reading on dosimeter
- Torn protective clothing
- Wet anti-Cs (unless using waterproof ones)

Which alarm is missing and does not require immediate exit?

- If the PCM alarms
  - contact an RCT
  - stay in the immediate area

Disregarding or Tampering with Alarms

- Jeopardizes the safety of personnel
- Can cause excessive personnel exposure
- Results in unnecessary spread of contamination
- Leads to disciplinary action

EO 5.6, 7.3

Emergency Assembly Areas

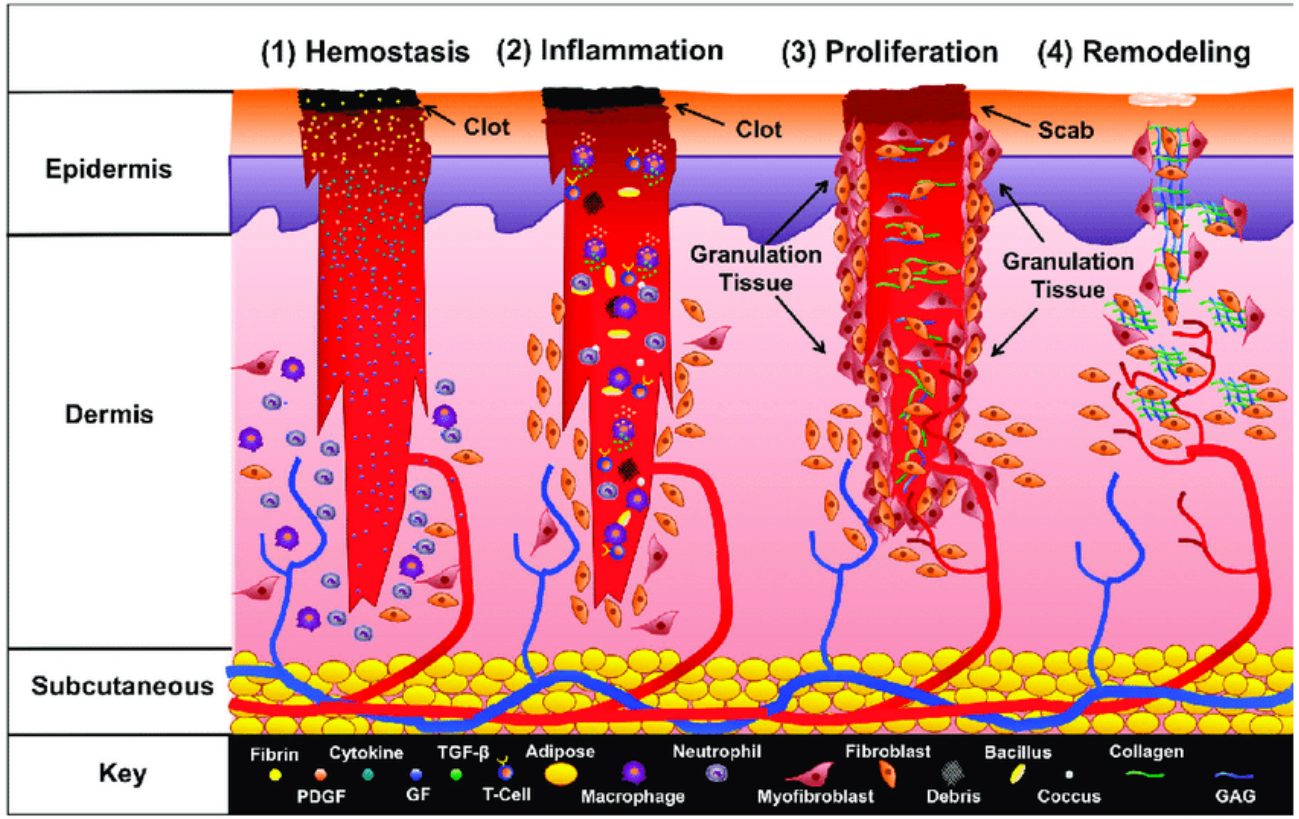
No commingling!

Major Personnel Injury

- Any head injury
- Major penetrating injury
- Disorientation or loss of consciousness
- Convulsions
- Loss of sensation or motor functions
- Limbs at abnormal angles
- Burns of the face, feet, hands, or genitals
- Any burn larger than the palm of your hand
- Extensive bleeding
- Abnormal breathing patterns
- Anything that you are uncomfortable with and think requires immediate treatment to prevent death or permanent disability

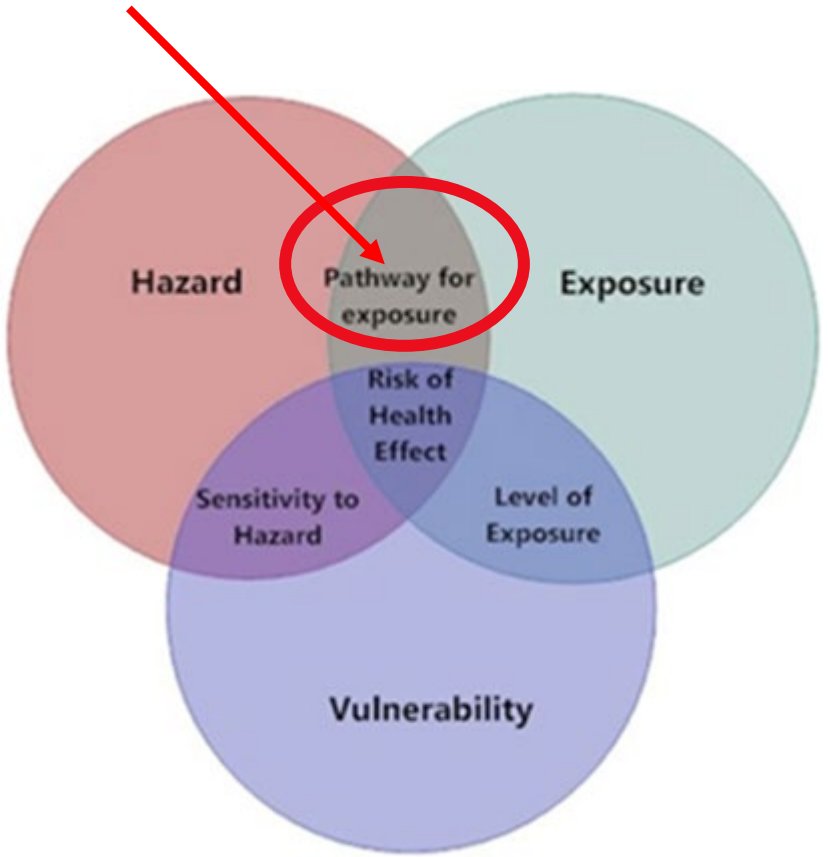
What is a Wound?

- A wound is defined as any compromise of the skin surface that could allow radioactive material to enter the bloodstream.
- This includes but is not limited to scabs, non-healed abrasions, lacerations, punctures, tattoos, piercings, blisters, rashes resulting in non-intact skin, and partial to full thickness burns.

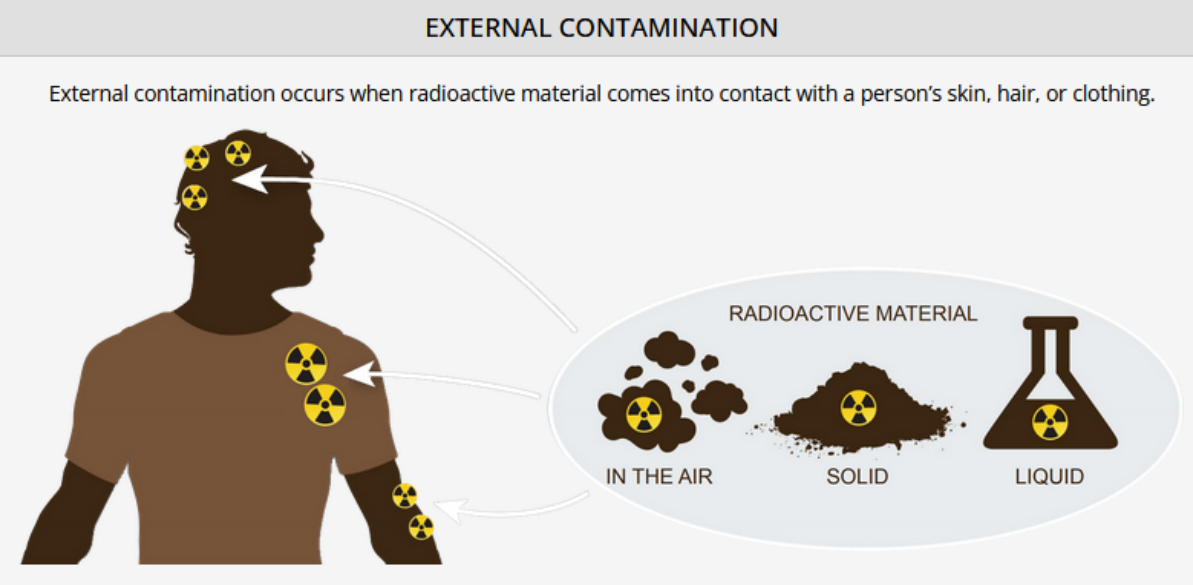


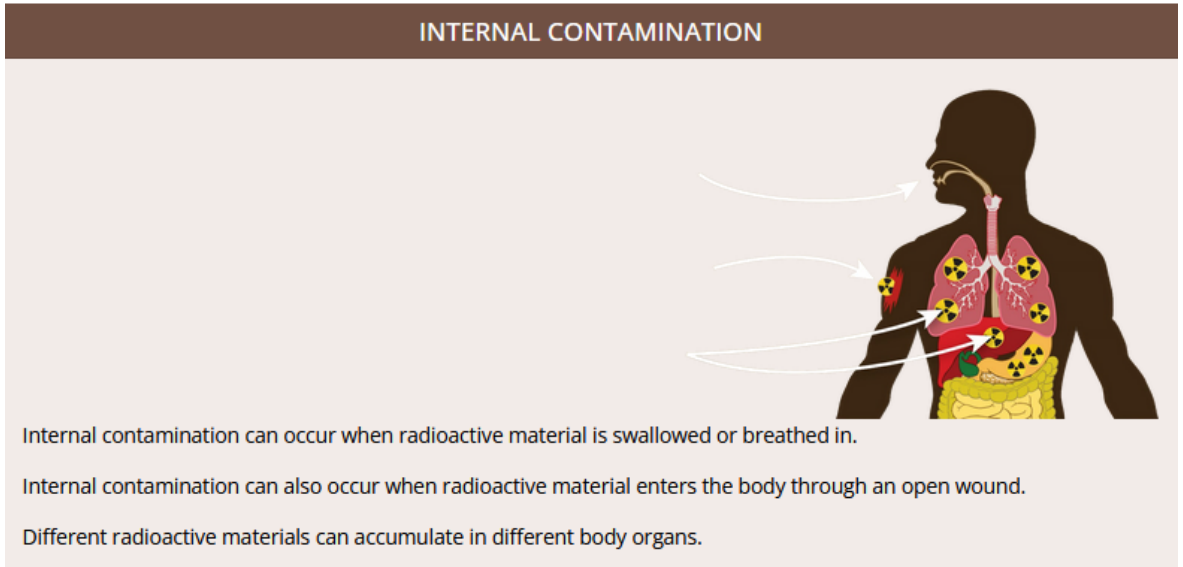
What is the risk of a wound in an area controlled for radiologic contamination?

- Intact skin provides a natural barrier to prevent radioactive material from entering the body.
- Wounds provide a potential entry point for radioactive material and must therefore be managed appropriately to minimize the risk of internal contamination.
- When managed properly, the risk of internal contamination due to the presence of a wound(s) can be significantly reduced.



The difference between external and internal contamination





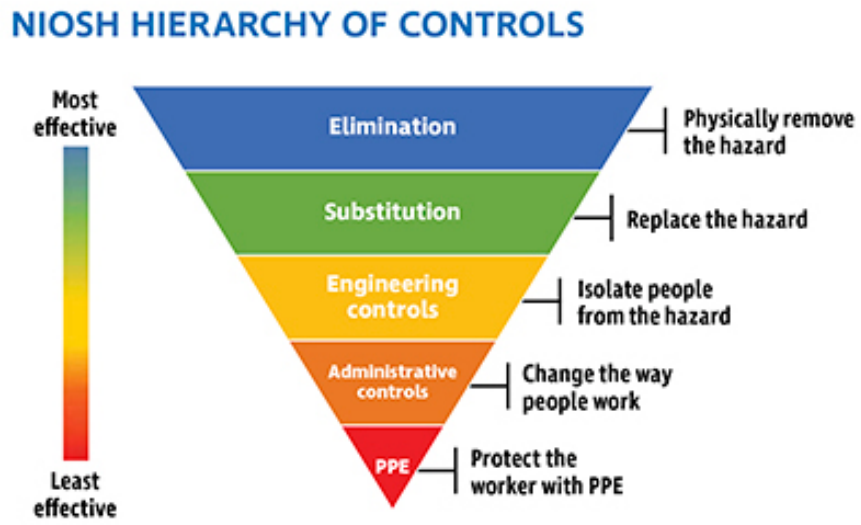
Health hazards:

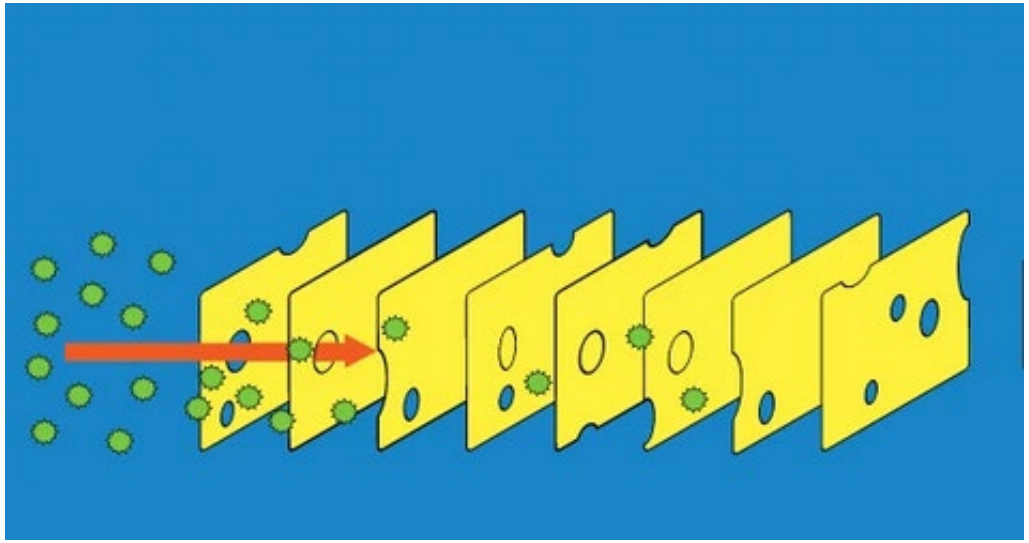
- Cutaneous radiation injury >> **requires a very large dose to skin**
- Mental health

Health hazards:

- Acute Radiation Syndrome
- Prenatal Radiation Exposure
- Cancer
- Mental health

How can we prevent internal contamination?





1. Be proactive about preventing wounds.
2. Disclose wounds before entering or working in certain areas controlled for radiologic contamination.
3. Put the proper dressing on wounds.
4. Perform safe work in accordance with the wound(s) and the dressing(s).
5. Continue to practice the other multi-layered approaches to safety already in place.

Response to Personnel Injury

- Major injury
  - Call 911
  - Administer first aid
  - Contact an RCT

Standard first aid takes priority!

Contamination concerns are secondary.

- Minor injury
  - Contact an RCT
  - Follow RCT instructions
  - Contact supervisor
  - Go to OCCMED with an RCT **if** a wound count is required
  - Go to OCCMED with a designee if no wound count is needed

Contamination control takes priority!

Administer first aid after decontamination.

Accident Breach, Leak, or Spill

- SWIMS
  - **S**top and evaluate the situation
  - **W**arn others of the hazard and ensure that someone contacts an RCT and area supervisor
  - **I**solate the area
  - **M**inimize exposure
  - **S**ecure unfiltered ventilation
- Follow facility-specific procedure priorities
  1. Safety for yourself and coworkers
  2. Environmental safety
  3. Safety of the facility and property

Emergency Dose Limits

The DOE guidance on emergency doses for these personnel is as follows:

- Protecting major property where the routine dose limit (5 rem per year) is not practicable.
  - The DOE guidance on the emergency level is 10 rem.
- Lifesaving or protecting a large population where the lower dose limit is not practicable.
  - The DOE guidance on the emergency level is 25 rem, if you do not volunteer or sign a consent form.
- Lifesaving or protecting a large population where doses can exceed 25 rem—**only on a voluntary basis, and only personnel fully aware of the risks involved may volunteer.**
  - The DOE guidance on this emergency level is greater than 25 rem (no upper limit) but ALARA still applies.

Note: *Response to these types of situations usually involves emergency response personnel who have received Emergency Responder Radiological Training.*

What Next?

After this course you will need to enroll in the Utrain courses for the examination and the practical.

Radiological Worker II Examination:

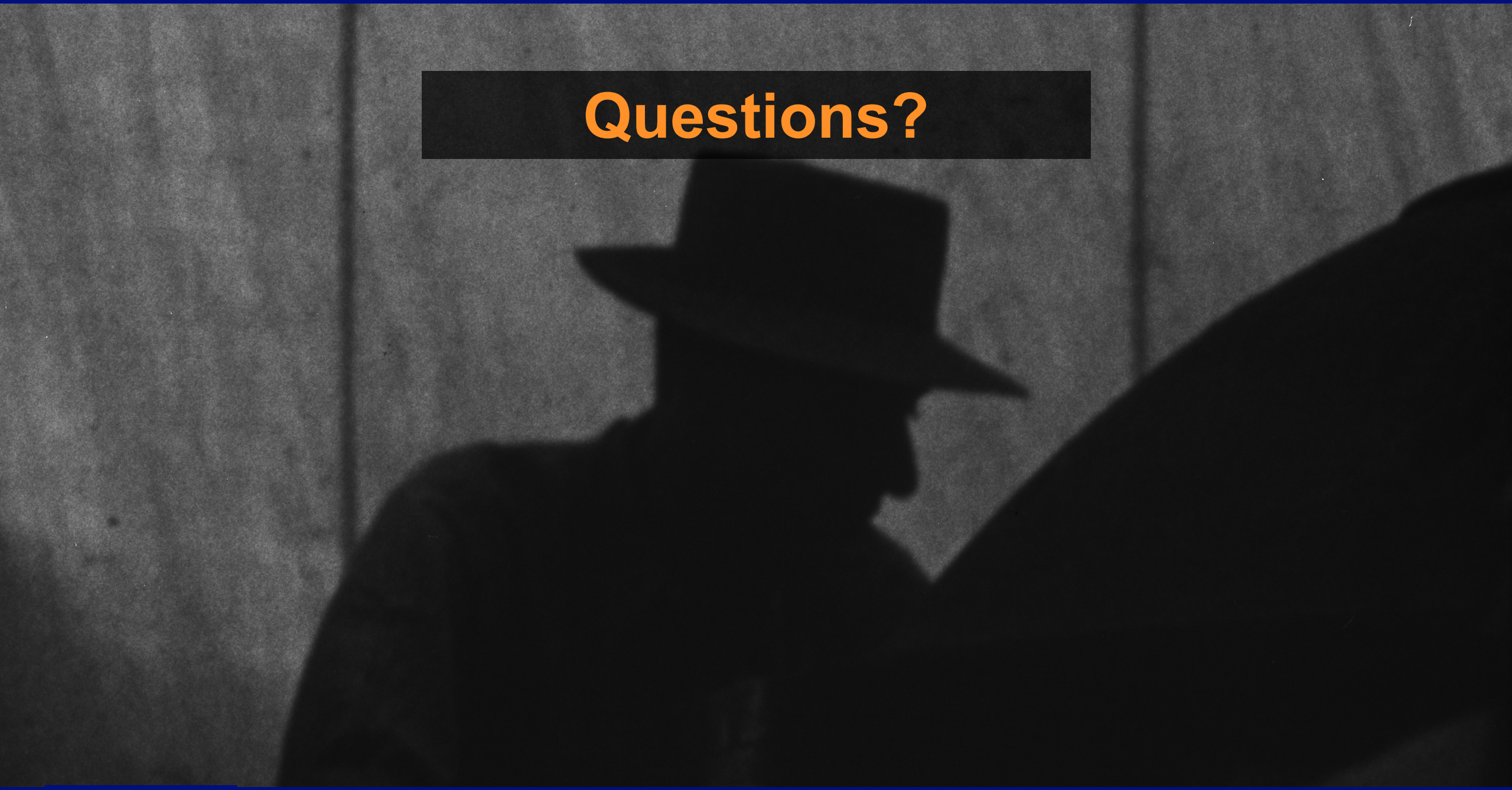
Email esh-registration@lanl.gov and request to take exam #12909.

Radiological Worker II Practical:

On Utrain look up item 57810 and find a class that works with your schedule and self-register.

Once you are enrolled in a practical you will have a course 12910 listed on your Utrain.

If you are taking the 24-month refresher, you can now take it on Utrain- exam #49525 (you do not take the practical more than once)


Questions?