Radiation Safety Training

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Why Train?

- NRC requirements for AU's
- NRC requirements for certain expected radiation levels
- To promote safe lab practice
- To inform users/non-users
- To prevent mistakes
- To prevent misinformation

First, some jargon:

- Nuclear Regulatory Commission, NRC
- Radiation Safety Officer, RSO
- Authorized User, AU
- Radioactive Isotope
- Radiation
- “As Low As Reasonably Achievable”, ALARA

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By law, our training must include the following:

- **Characteristics of Ionizing Radiation**
  1. , $^-$, –emission
  2. Penetrating power and Halflife
- **Units of Radioactive Dose and Quantities**
  1. Curies, Roentgens, Rads, and REM
  2. Permissible Limits and 10% Rule
  3. Naturally-occurring radiation
- **Radiation Protection Principles**
  1. Time, Distance and Shielding
  2. ALARA
- **Instrumentation**
  1. Different Radiation, Different Detector
- **Bio-Hazards of Exposure**
  1. Somatic, Genetic and Embryonic
- **Hands-On Use**
  1. Safety/Emergency Procedures
  2. Ordering, Receiving, Opening Packages
  3. Disposal
  4. In-House rules and Postings

Characteristics of Ionizing Radiation

Alpha ( ) Particles

Massive Size - He^4 nucleus

Charge of +2e

Slow Speed

Beta ( ) Particles

Very small - electron

Charge of +e

High Speed

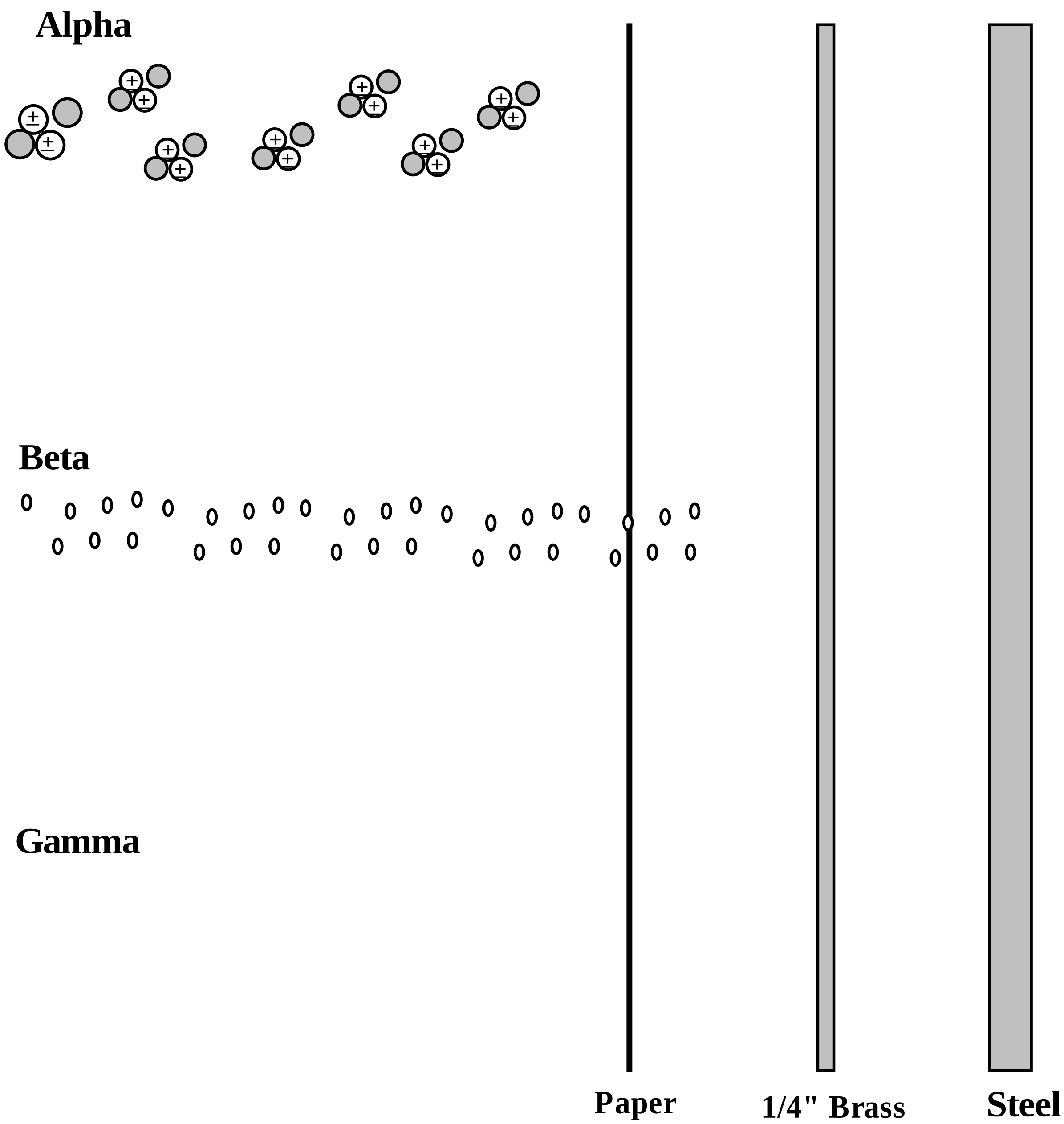
Gamma () Ray

No mass

No Charge

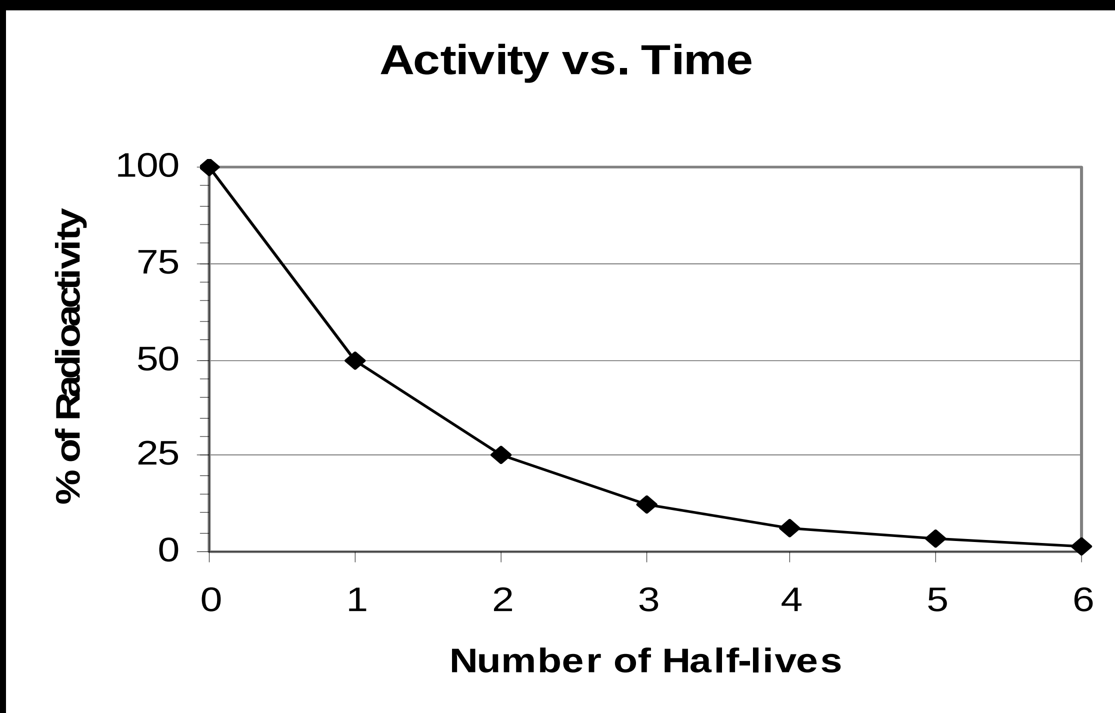
Speed of Light

Called a Photon


Alpha
Beta
Gamma
Paper
1/4" Brass
Steel

Halflife

The time it takes for a level of radioactivity to decay to 1/2 of its initial value



For example:

Starting with 60 mCuries of ^{32}P, $t_{1/2}$= 14.3 days, the activity after 3 half-lives (42.9 days) will be 7.5 mCuries.

Units of Radioactivity

Curie- a measure of decays per unit time

1 Ci = 37 x 10^9 decays per second

1 mCi = 37 x 10^6 dps

1 Ci = 37,000 dps

Roentgen- a measure of the charge produced in air from ionization by x-rays and gamma rays

R, mR, R,-- coulomb/kilogram

rad- a measure of the absorbed dose, the energy deposited by ionizing radiation in a unit mass of material

1 rad = 100 ergs/gram

rem- Dose equivalent - scale which equates the relative hazards of the various radiations: 1 rem = Q x (#rad) where,

Q = 1(,   and 20(

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Additional Limits

Occupationally exposed minors:

500 mrem/year or 0.25 mrem/hr

Declared, pregnant personnel :

500 mrem during gestational period

Members of the public :

100 mrem/yr or

2 mrem in any one hour

Personal Monitoring

-Required if individual is likely to receive a dose >10% of limits or 500 mrem in a year or 0.25 mrem/hr

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For comparison, our readings should never read above .05 mrem/hr!

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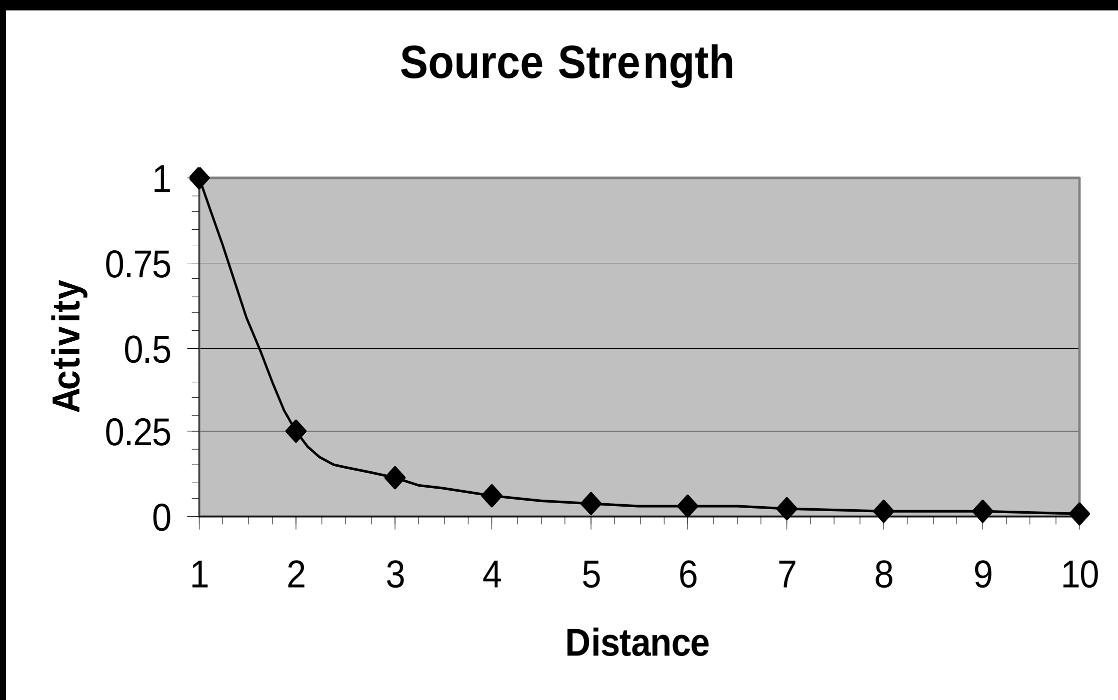
Distance

The strength of a radioactive source decreases with the square of the distance from it.



So, spend less <u>time</u> at short <u>distances</u> and more <u>time</u> at long <u>distances</u>!

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Shielding

- Alpha (particles are totally absorbed by a few centimeters of air or few sheets of paper
- Beta (particles are stopped in a few meters of air or a few centimeters of plexiglass.

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Instrumentation

Different Radiation, Different Detector

At our disposal for the detection of radioactivity is:

-Geiger-Mueller Pancake Probe

-Geiger-Mueller Normal Probe

-Bicron R Survey Meter

-NaI Gamma () Probe

-Liquid Scintillation Counter

Now each of these detectors has its own application and only one measures exposure. They cannot be depended on to detect all types of radiation.

Let’s look at the applications…..

Isotope	Radiation Type	Energy (keV)	Halflife	Monitor	Exposur e
H^3		18.6	12y	LSC	
C^{14}		157	5730y	GM/LSC	R
P^{32}		1709	14.3d	GM	R
P^{33}		249	25d	GM	

Now, how do we use each detector and what are we reading when we do?

Detectors

- GM Probes
  - Detect / radiation
  - Reads out milli-roentgen (mr)/hr
  - Only used for surveys, not for exposure
- Bicron Survey Meter
  - Only detector that measures exposure
  - Detects all radiation
- NaI Gamma () Probe
  - Primarily a detector.
  - Will indicate presence of decays through secondary x-rays
  - Need thin window probe for I^{125}
- Liquid Scintillation Counter
  - Used primarily to detect presence of H^3, C^{14}, S^{35} and other low energy radiation.
  - Requires “Swipe-Test”

Bio-Hazards of Exposure

We will group the physiological affects of radiation exposure into three groups:

-Somatic (individual)

-Genetic (passed on)

-Embryonic (in utero)

Let’s discuss radiation risk factors and the prevalence of each effec due to radiation exposure...

Radiation Risk Factors

- Type and quantity of radiation
- Rate and duration of exposure
- Part of body exposed
- Gender and age at exposure
- Time since exposure

Somatic Effects

- Large doses of radiation may cause leukemia, cancer.
  - Evidence from animal studies, radiologists, uranium miners, dial painters, medical patien atomic weapons.

- Prompt Effects (early)
  - Result from high doses in a short time (e.g. 1 rem in few hours)
  - Damage results from killing cells
  - Vomiting, diarrhea, fever, hair loss
  - Weight loss
  - 450 rems—LD for 50% in 60 days

- Delayed Effects
  - Result from low doses over time
  - Effects are statistical over long period

Somatic Effects

Since it is impossible to attribute a single individual's cancer to a single cause, the only way to designate radiation as a cause is to look at statistics with large sample populatio

Data

Normal incidence of cancer is ~30%

Normal death rate due to cancer is 2

Cancer risk due to radiation

0.04% / rem (for high dose rate)

So if you were to absorb 1 rem in a rapid manner the overall risk grows t

20.04%

(Data from Committee on the Biological Effects of Ionizing Radiation, National Academy of Sciences)

Genetic Effects

Our only data, similar to somatic

Embryonic Effects

Effects suffered by an individual due to exposure while still an embryo/fetus

Remember that the NRC limit for the duration of a pregnancy is 500 mrem or 10% of the normal yearly dose limit if declared.

Childhood Cancer

-*At 1 rem maternal dose*

-*Excess deaths = 0.6/1000*

Mental Retardation

-*Single dose of 1 rad at 8-15 wks*

Risk = 4/1000

Hands-On Use

- Safety/Emergency Procedures
- Ordering, Receiving, and Opening Packages
- Real-time Inventory & Disposal
- In-house rules and postings

APPENDIX B

Operating Procedures
for the
Safe Use of Radioactive Isotopes

1) All use of radioisotope material shall be conducted under the supervision of a faculty member certified as an Authorized User (AU).

2) The AU shall limit the quantity of radioactive material used by students under his supervision so as not to exceed the maximum dose allowed by regulation.

3) Adequate personal protection equipment must be worn or used by all individuals using radioactive material. This shall include, but is not limited to, rubber gloves and a laboratory coat.

4) Active participation in laboratory exercises during which radioactive isotopes are utilized by students that are known to be pregnant is strictly prohibited.

5) Eating, drinking or smoking in the laboratory is not permitted.is tiodJ17.0dc.

8) No person shall work with liquid radioactive materials if he has any breaks in the skin without first covering the break with some form of protective equipment All such breaks shall be reported to the instructor in charge before work begins.

9) Active liquid wastes shall be poured into labeled containers or into approved “hot” sinks in concentrations conforming to state guidelines. They shall never be poured into a standard drain.

10) Active solid wastes and contaminated materials should be placed in trash cans labeled “contaminated” or in designated containers.

11) Active materials and contaminated materials are to be retained within the radioisotope laboratory and at specific points within the laboratory.

12) All wounds, spills and other emergencies shall be reported to an approved user immediately.

13) Before leaving the laboratory, all written records of isotope usage, clean-up, surveys and emergencies (if any) must be completed by an Authorized User.

14) No ancillary personnel will be allowed in a radiation area without direct supervision.

Emergency Procedures

In emergency or accident situations involving radioactive materials, th following steps should be taken:

1) RESTRICT ACCESS: Persons in the immediate area not contaminated in the incident should be asked to leave the area. Establish a restricte area boundary, limiting access to the area to authorized personnel only.

2) MAINTAIN SURVEILLANCE: The restricted area must be kept under constant, direct supervision by an Authorized User (AU) or the Radiation Safety Officer (RSO) until area is deemed safe for occupancy.

3) NOTIFY: The Authorized User directly supervising the use material involved in the accident should be notified immediately. In the case of spills assessment of the accident should be made to determine if accident is minor or major and the proper procedures for which should be followed.

Minor Spills of Liquids and Solids

--Notify persons in the area that a spill has occurred.

--Prevent the spread of contamination by covering the spill with absorbent paper. (Paper should be dampened if solids are spilled).

--Clean up the spill, wearing disposable gloves and using absorbent paper.

--Carefully fold the absorbent paper with the clean side out and place in a plastic ba for transfer to a radioactive waste container. Put contaminated gloves and any other contaminated disposable material in the bag.

--Survey the area with an appropriate low-range radiation detector survey meter other appropriate technique. Check the area around the spill for contamination. Also check hands, clothing and shoes for contamination.

--Report the incident to the RSO promptly.

--Allow no one to return to work in the area unless approved by the RSO.

--Cooperate with the RSO and AU (e.g., investigation of root cause, provision of requested bioassay samples).

--Follow the instructions of the RSO/AU (e.g., decontamination techniques, surve provision of bioassay samples, requested documentation).

Emergency Procedures

Major Spills of Liquids and Solids

--Clear the area. If appropriate, survey all persons not involved in the spill and vacate the room.

--Prevent the spread of contamination by covering the spill with absorbent paper (paper should b dampened if solids are spilled), but do not attempt to clean it up. To prevent the spread of contamination, limit the movement of all individuals who may be contaminated.

--Shield the source only if it can be done without further contamination or significant increase in

Ordering, Receiving and Opening Packages

The presence, form, and disposition of any licensed radioactive material on th campus of USI must be documented.

Documentation begins with the order o the material and concludes when that material is completely used and/or disposed of.

Procedures are in place for:

--Ordering isotopes

--Receiving and opening packages

Ordering Radioactive Material

- All orders begin with a completed PO submitted to the RSO for approval
  - PO will not be forwarded without sign-off by RSO
- Original PO is forwarded by the AU to Purchasing
- Copy of PO is maintained by RSO
- Upon receipt of package, a copy of each the following must be forwarded to the RSO:
  - Shipping Manifest
  - Radioactive Shipment Receipt/Usage Report

Receiving and Opening Packages

Care is taken in the receipt and opening of packaging for multiple reasons:

-To assure integrity of packaging

-To assure that the isotope you received is isotope you ordered

-To assure that how much you received is much you ordered

-To assure that the form of the radiation you purchased is the form that you received

Receiving and Opening Packages

- Receipt of material is the responsibility of the AU in accordance with procedures in Appendix A of our application
- Once a package is delivered and the AU is notified of such, receiving procedures should take place as soon as possible
- Required for proper receipt is a GM pancake probe and a Radioactive Shipment Receipt/Usage Report

RADIOACTIVE SHIPMENT RECEIPT/USAGE REPORT

Real-time Inventory & Disposal

- Notice that the Radioactive Shipment Receipt/Usage Form serves a dual role:
  - Records the receipt of material
  - Records the real time use and disposal of the contents of that shipment
- Each container of a shipment requires a form
- When a container is emptied, the form is completed and returned to RSO

Disposal of Radioactive Waste

- The methods of disposal of radioactive material depend on:
  - Form (solid or liquid)
  - Type (
  - Half-life (short- vs. long-lived)

- Items requiring special storage consideration are:
  - Used/Unused portions of isotope material
  - Contaminated items such as gloves, absorbent paper, LSC vials, etc.

- Methods of disposal available to us are:
  - Decay-in-storage (DIS)
  - Release into sanitary sewage
  - Disposal as if not radioactive

Decay-in-storage

Disposal in Sanitary Sewers

- All of our permitted levels of radiation which are liquids or soluble forms can be disposed of in designated “hot-sinks”
  - 5 Ci of H^3, 1 Ci of C^{14}, 1 Ci of all others
- Disposal of these forms must be accompanied by adequate dilution by running water during disposal
- Disposal must be limited to designated ho sinks
  - Provides notice to any maintenance personne potential radioactivity
  - Provides containment of waste to specified areas

Disposal of Waste

In-House Rules and Postings

- Surveys of Labs / Records
- Wipe tests / Records
- Bi-annual Inventory / Records
- Student Training and Use of isotop during Pregnancy / Records
- Postings

Surveys / Records

- Places to Survey
  - Facilities
  - Equipment
  - Personnel
  - Restricted and Unrestricted areas

- Types of Surveys
  - General Area
  - Contamination
    - Fixed vs. Removable
  - Leak Tests

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Fixed vs. Removable Contamination

- Once you have found an area of contamination, you must determine it is fixed or removable through the application of a wipe test.
  - Wipe area with cloth disk
    - 100 cm^2 area per disk
  - Place in vial with liquid scintillation material
  - Place vial in LSC for measurement and record
- If contamination is removable, proper cleanup procedures should be followed

Bi-annual e90nventory /

Student Training and USI Pregnancy Policy

- Before any student may use radioactive isotopes, he or she must undergo documented training
- It is the policy of USI not to allow students that have declared their pregnancy to us use radioactive isotopes
- A student's disposition to use isotopes must be affirmed through a signature on Appendix D

APPENDIX D

Student Training Certification
and
Disposition to Safely Handle Radioactive Material

Postings / Signs

- Required by Code of Federal Regulations (CFR) are the following postings:
  - 10 CFR Part 21
  - Section 206 of the Energy Reorganization Act of 1974
  - Procedures
  - NRC Form 3
  - Notices of Violation
  - Copies of NRC Regs (19 and 20)

Signs

Wherever you have radioactive material present, there must be a sign indicating as such

The type of sign you post is significant, if not to you, to the NRC

“Radioactive Materials”

indicates < 2.5 mrem/hr

“Radiation Area”

indicates >2.5 mrem/hr