Radiation Safety

At CSULA

Contact Information

- Brian Magness – Radiation Safety Committee (RSC) Chair
  - 323-3433-2111
- Jeremiah J. Diaz – Chemical & Radiation Safety Officer (RSO)
  - 323-343-3546
- Andrew Wilson – Biological Safety Officer / Hazardous Materials Technician
  - 323-343-6359

Or call Environmental Health and Safety at:

323-343-3531

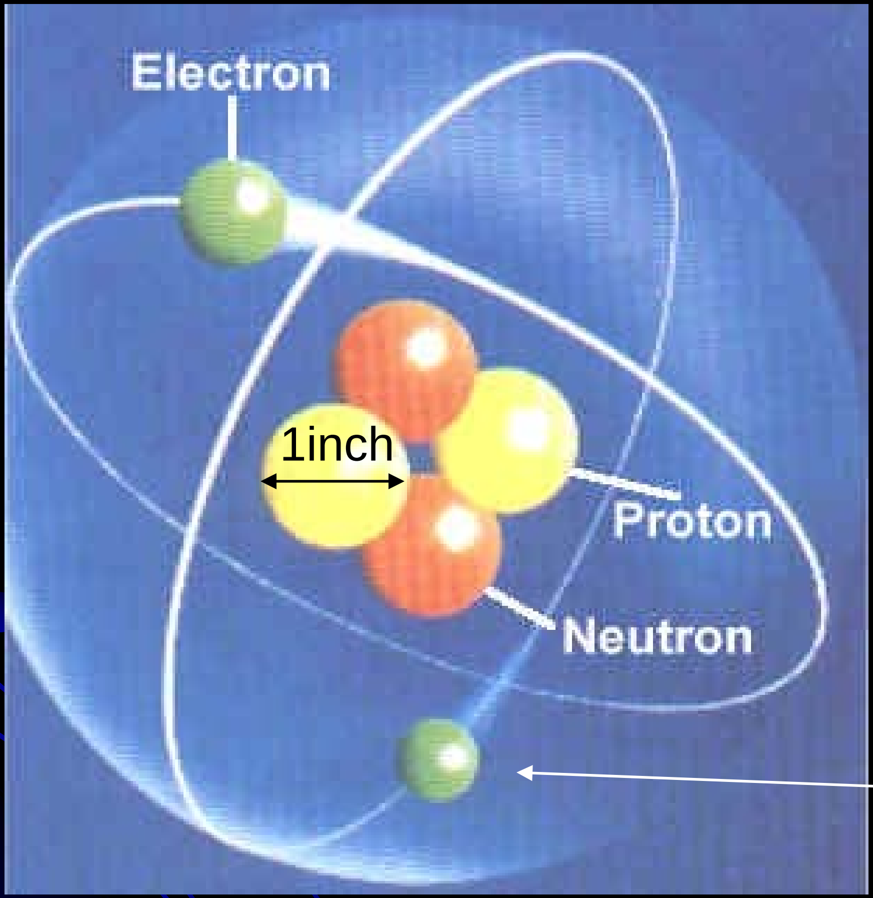
Regulatory Agencies

- Nuclear Regulatory Commission

- California Department of Public Health
  - Radiological Health Branch
    - **Radiation Control Law** (Health & Safety Code Sec. 114960 et seq.)
    - **Radiologic Technology Act** (Health & Safety Code Sec. 27(f).)
    - **Nuclear Medicine Technology Certification** (Health & Safety Code Secs. 107150 through 107175.)

Regulations implementing the above laws are in:
Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapters 4.0, 4.5, & 4.6.

Atomic Structure



Proton Mass = 1.672 x 10^{-27} kg
= 1.007 u

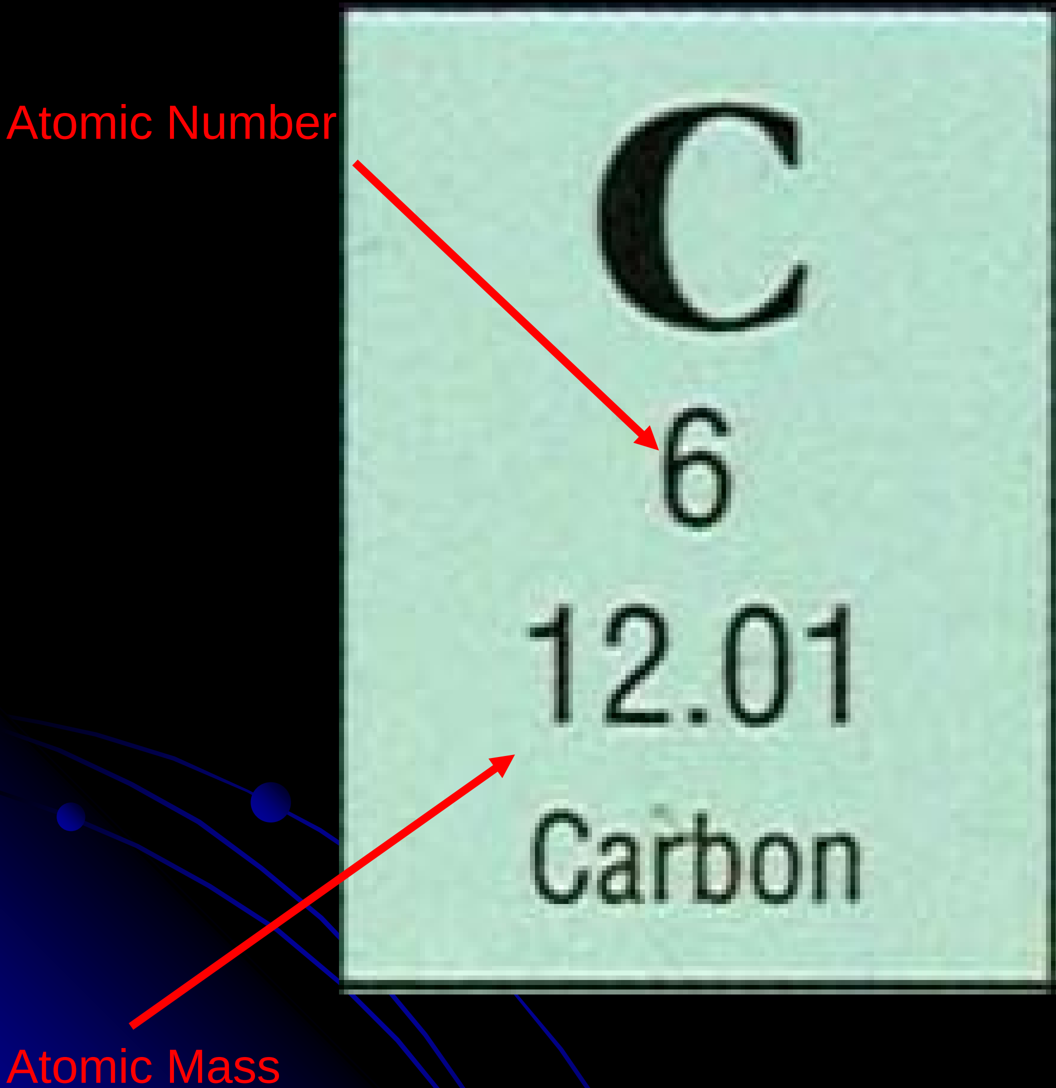
Neutron Mass = 1.674 x10^{-27} kg
= 1.008 u

Electron Mass = 9.109 x 10^{-31} kg
= 0.0005 u

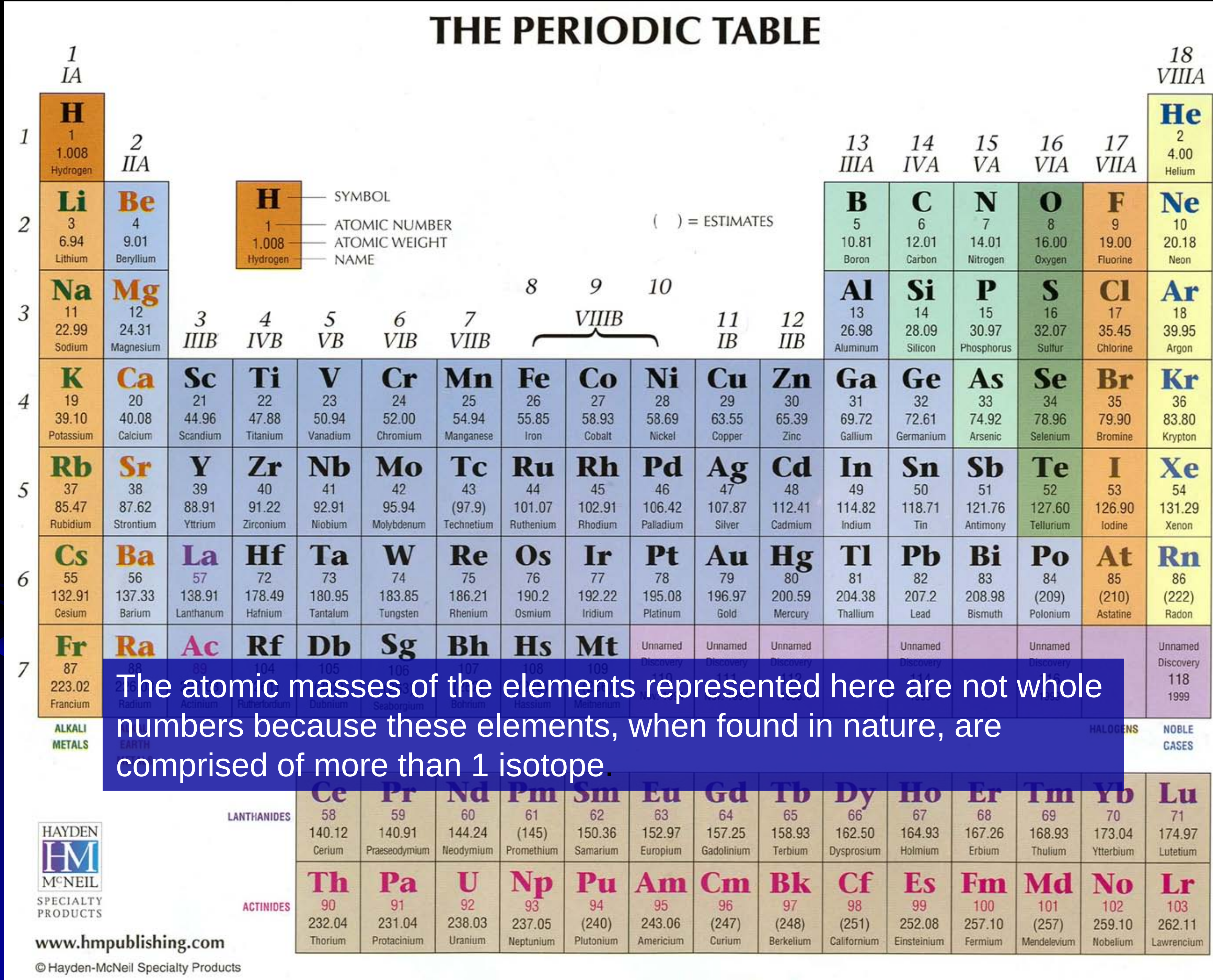
u = Atomic Mass Unit

If this model were to scale, this electron would be **over 2000 feet away**

The amount of empty space in an atom helps to explain other items discussed later in this presentation

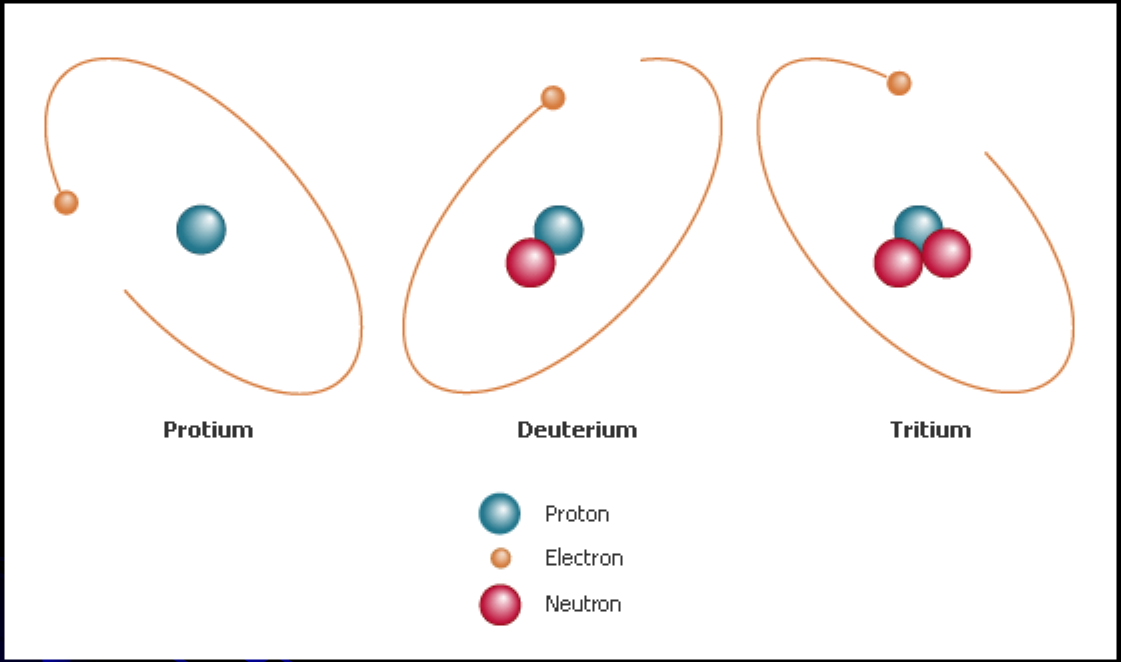


The 6 represents the number of protons in the nucleus, and the 12.01 represents the atomic mass of this element in grams per mole. Since electrons have a negligible mass, the atomic mass is derived predominantly from the number of protons and neutrons in the nucleus of an atom. Carbon usually has 6 protons and six neutrons (which would yield an atomic mass of 12) but, some carbon atoms have fewer or greater numbers of neutrons in their nuclei. As a result, an average of the atoms in a mole of carbon would result in an atomic mass of 12.01. Atoms of a given element that have different numbers of neutrons are referred to as isotopes



The atomic masses of the elements represented here are not whole numbers because these elements, when found in nature, are comprised of more than 1 isotope.

The Basics



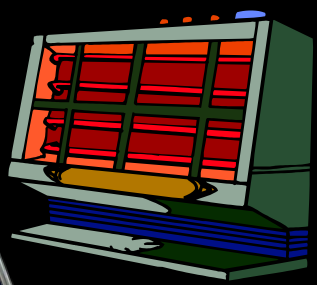
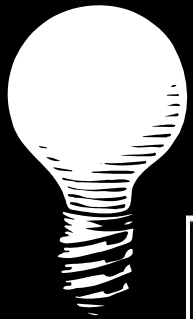
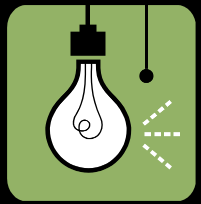
Displayed on this slide are three isotopes of Hydrogen. Below each isotope are three different methods for writing the elemental symbol for each isotope.

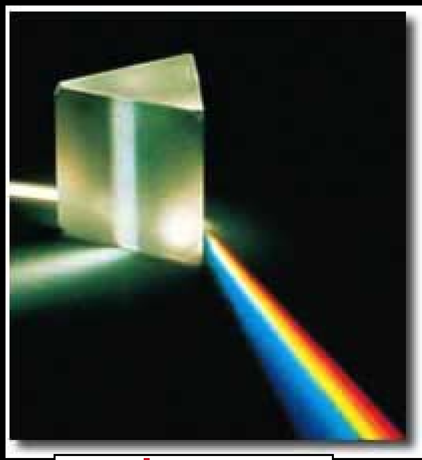
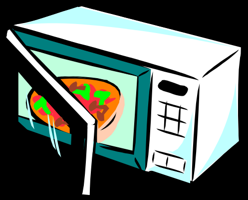
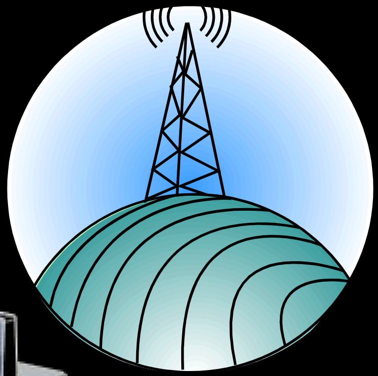
H1	H2	H3
H-1	H-2	H-3
^{1}H	^{2}H	^{3}H

What is Radiation?

Radiation is energy emitted as electromagnetic waves or subatomic particles.

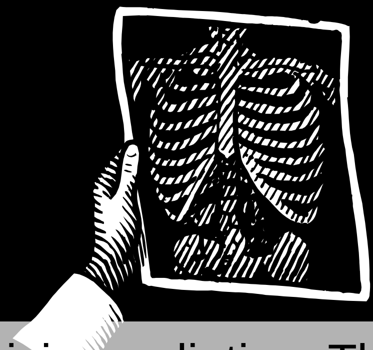
Sources of Radiation


The items pictured hear are sources of Non-ionizing radiation. While these items are, in fact, sources of radiation, they are not the type of radiation most people think of when speaking of “Radiation”. The hazards that are the subject of this training do not result from exposures to Non-ionizing Radiation.

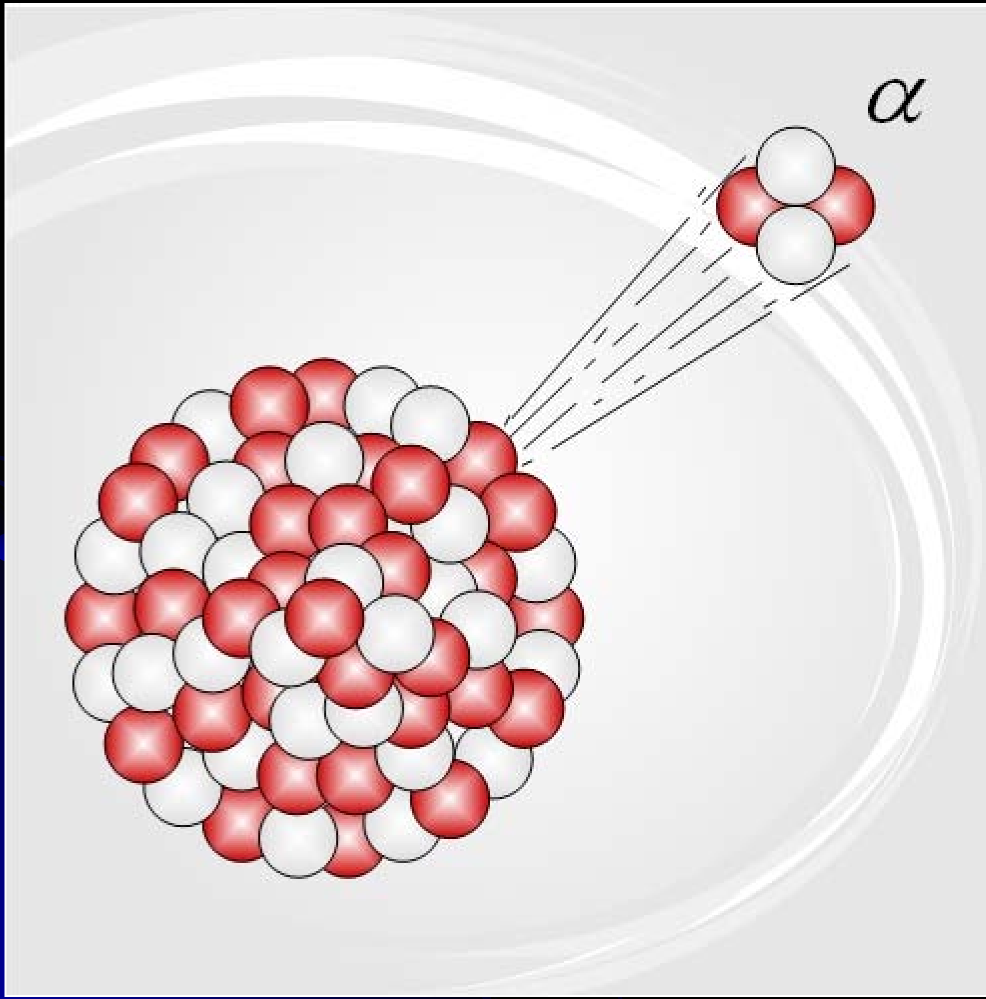
Sources of Radiation



These items ARE sources of ionizing radiation. This is the type of radiation that most people think of when they hear the word “radiation”. Ionizing radiation, and its associated hazards, are the focus of this presentation.

Alpha Decay

Alpha decay occurs when an unstable nucleus releases two neutrons and two protons, i.e. a helium nucleus



$^{238}U \rightarrow {}^{234}Th + \alpha$

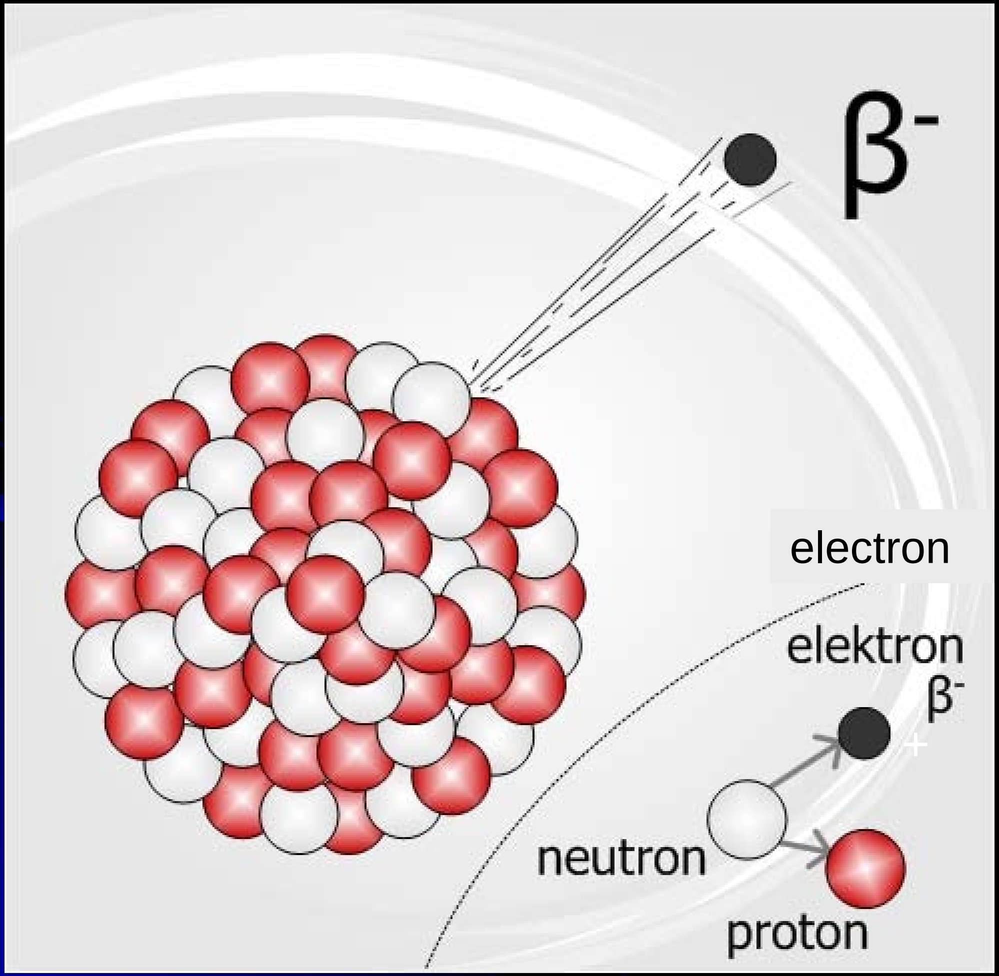
Alpha Emitters

^{238}U ^{234}Th ^{222}Rn

^{210}Po ^{241}Am

Beta Decay

Beta decay occurs when an unstable nucleus becomes stable by converting a neutron into a proton and a negatively charged beta particle. Beta particles are electrons that are emitted from the nucleus.



$$^{32}P \rightarrow {}^{32}S + \beta^-$$

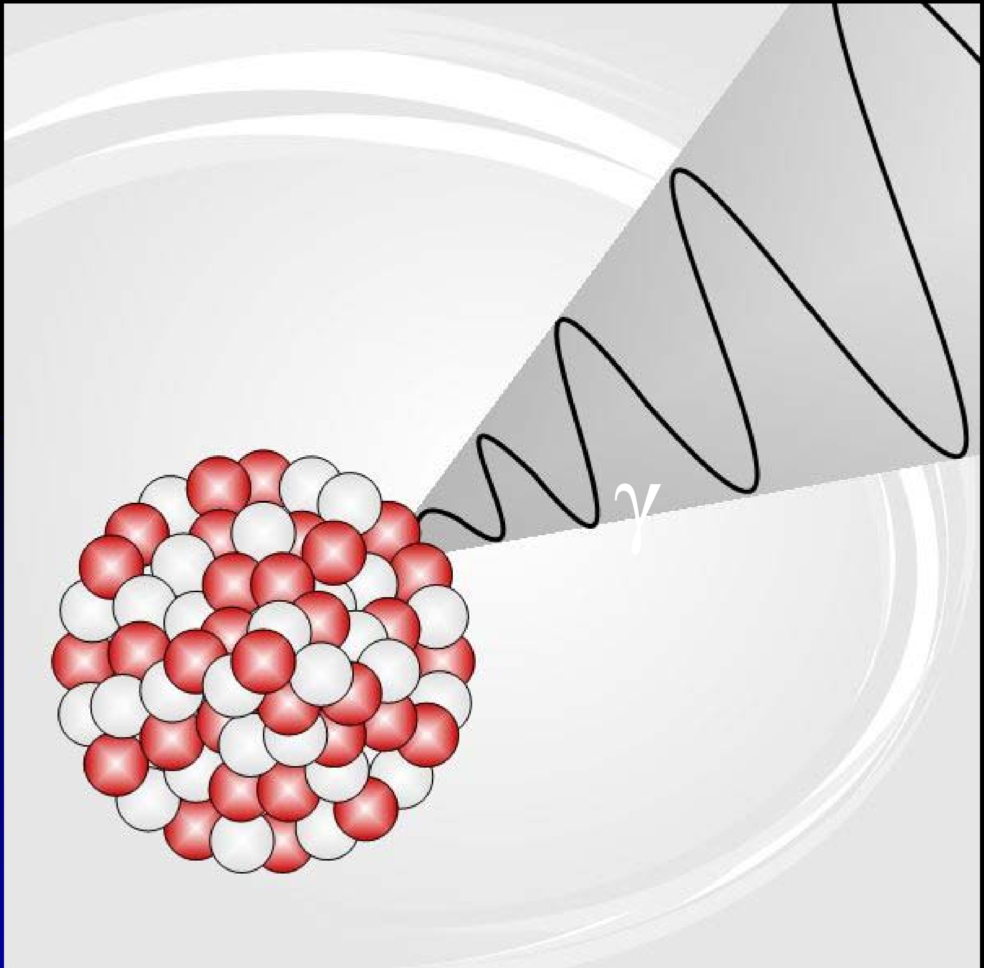
Beta Emitters

^{3}H ^{32}P ^{35}S

^{14}C ^{90}Sr

Gamma Emission

A nucleus in an excited state it can jump to a lower state and emit a photon/gamma ray. Gamma emission is usually associated with alpha or beta emission.



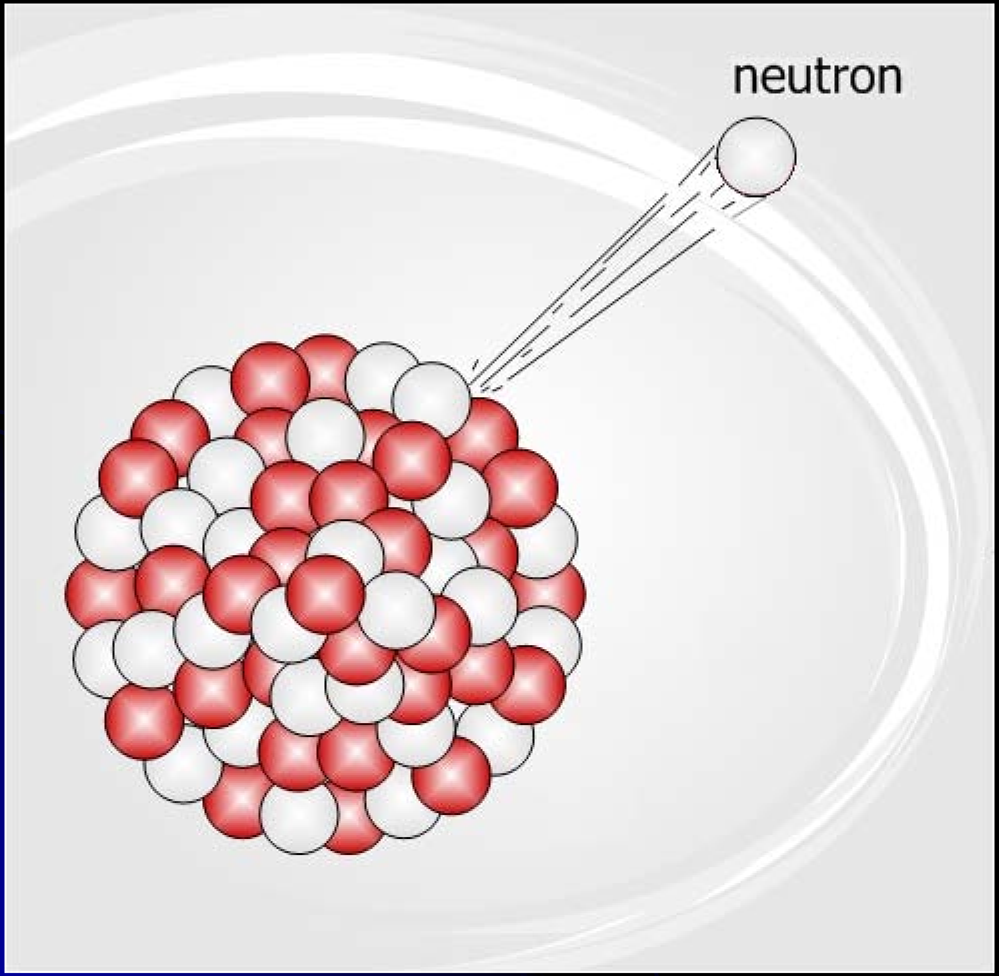
Gamma Emitters

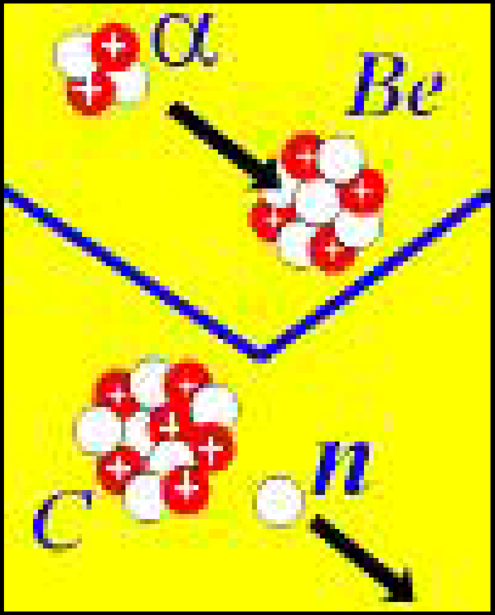
^{125}I ^{60}Co (^{137}Ba)

^{137}Cs ^{51}Cr

Neutron Emission

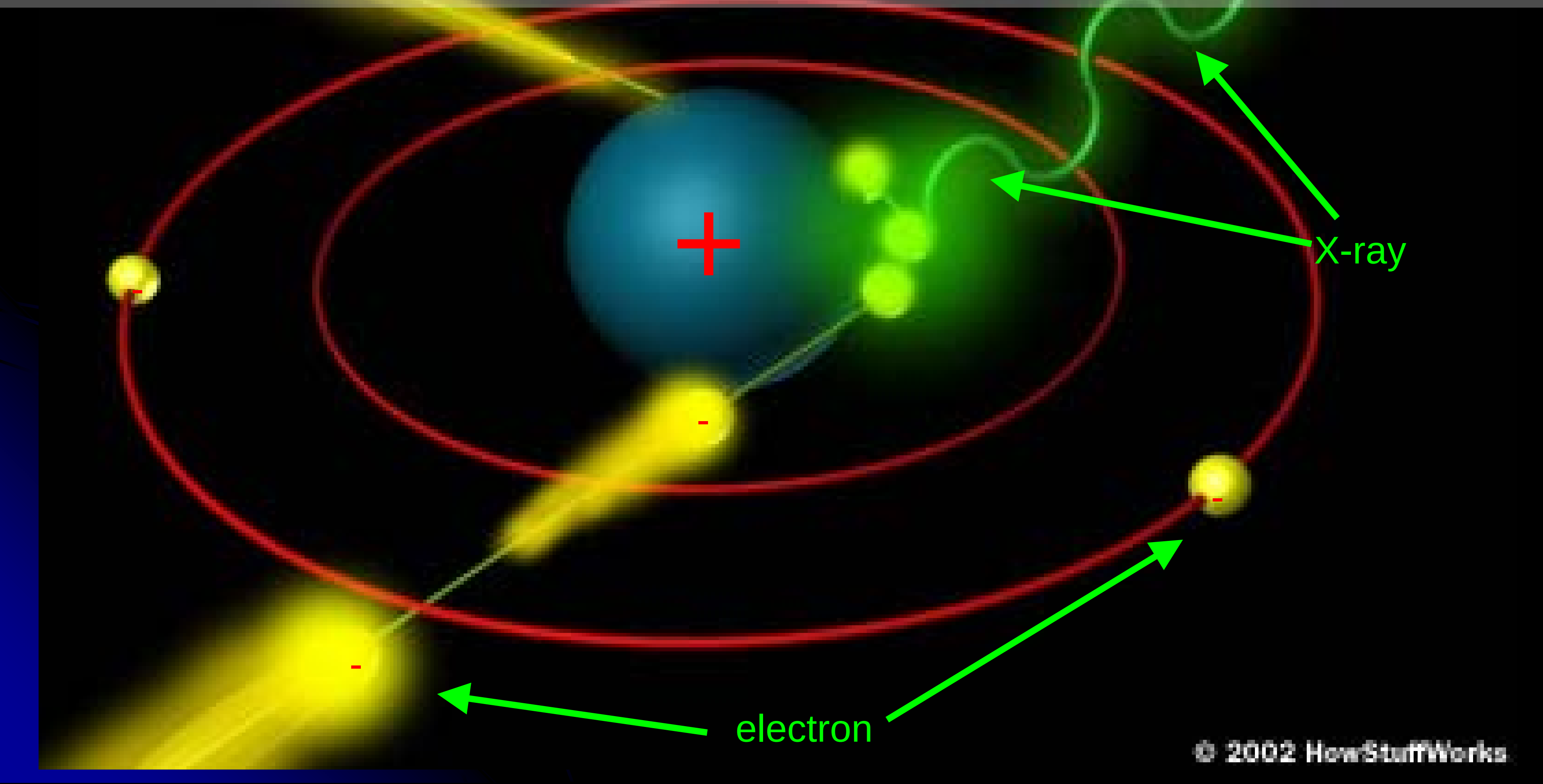
An unstable nucleus can becomes stable by emitting a neutron. The process shown on the right is a common way of generating neutrons.





Bremsstrahlung

When an electron’s velocity is decreased by interaction with the nucleus of an atom, as in this diagram, the difference in energy is given off as x-rays. This is known as Bremsstrahlung radiation. In order to avoid generating this type of radiation, never shield high energy beta emitters with lead. Acrylic is a better choice.

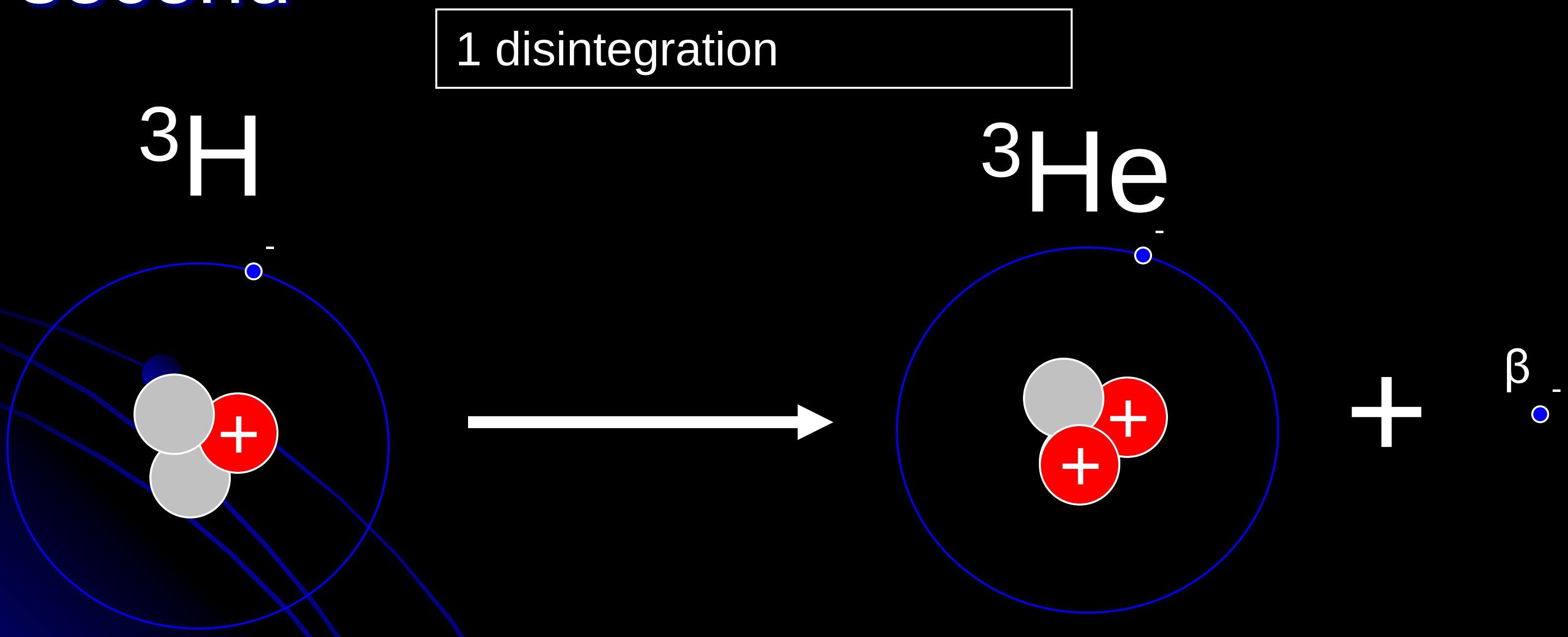


Ionizing Radiation Makes Ions

- When ionizing radiation interacts with matter it creates ions by removing or adding electrons.
- For example:
  - Gamma rays may excite an electron to the point that it is released from the valence shell
  - A beta particle may be captured in the valence shell
  - Alpha particle may steal electrons from an atom

Units of measure: Activity

- **Disintegrations per second (dps)** - number of atoms that radioactively decay in one second



- 1 Curie (Ci) = 37 billion dps = 37GBq
  - SI unit: 1 Becquerel (Bq) = 1dps

Units of measure: Exposure

- Roentgens (R) – charge produced in air from ionizations by x-rays or gamma rays

  - SI Unit

  $1R = 2.58 \times 10^{-4}$ coulomb/kilogram (C/kg)

Units of measure: Absorbed Dose

- Radiation absorbed dose (rad) – energy deposited by ionizing radiation in a unit of mass of material
- 1 rad = 100 ergs / gram = 100 Grey
  - SI unit

    1 Grey = 1J/Kg

Units of measure: Dose Equivalent

- **Roentgen Equivalent Man (rem)** – used to equate relative hazard of various types of radiation

rem = rad x Q

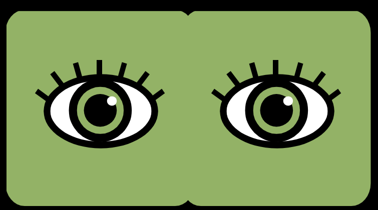
Radiation Type	Q
Alpha	20
Beta	1
Gamma & x-rays	1

SI Unit
100 rem = 1 Sievert (Sv)

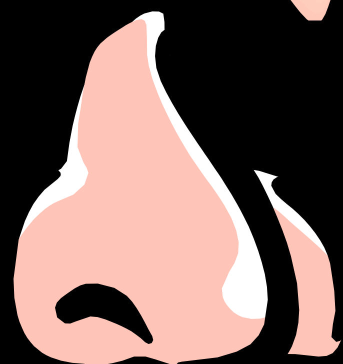
How do We Detect Ionizing Radiation?

- Can't touch it.

- Can't see it.



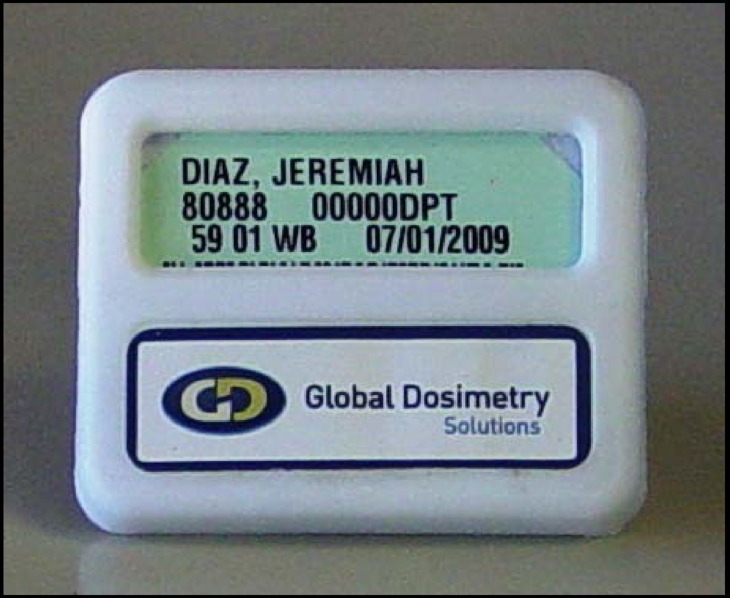
- Can't smell it.



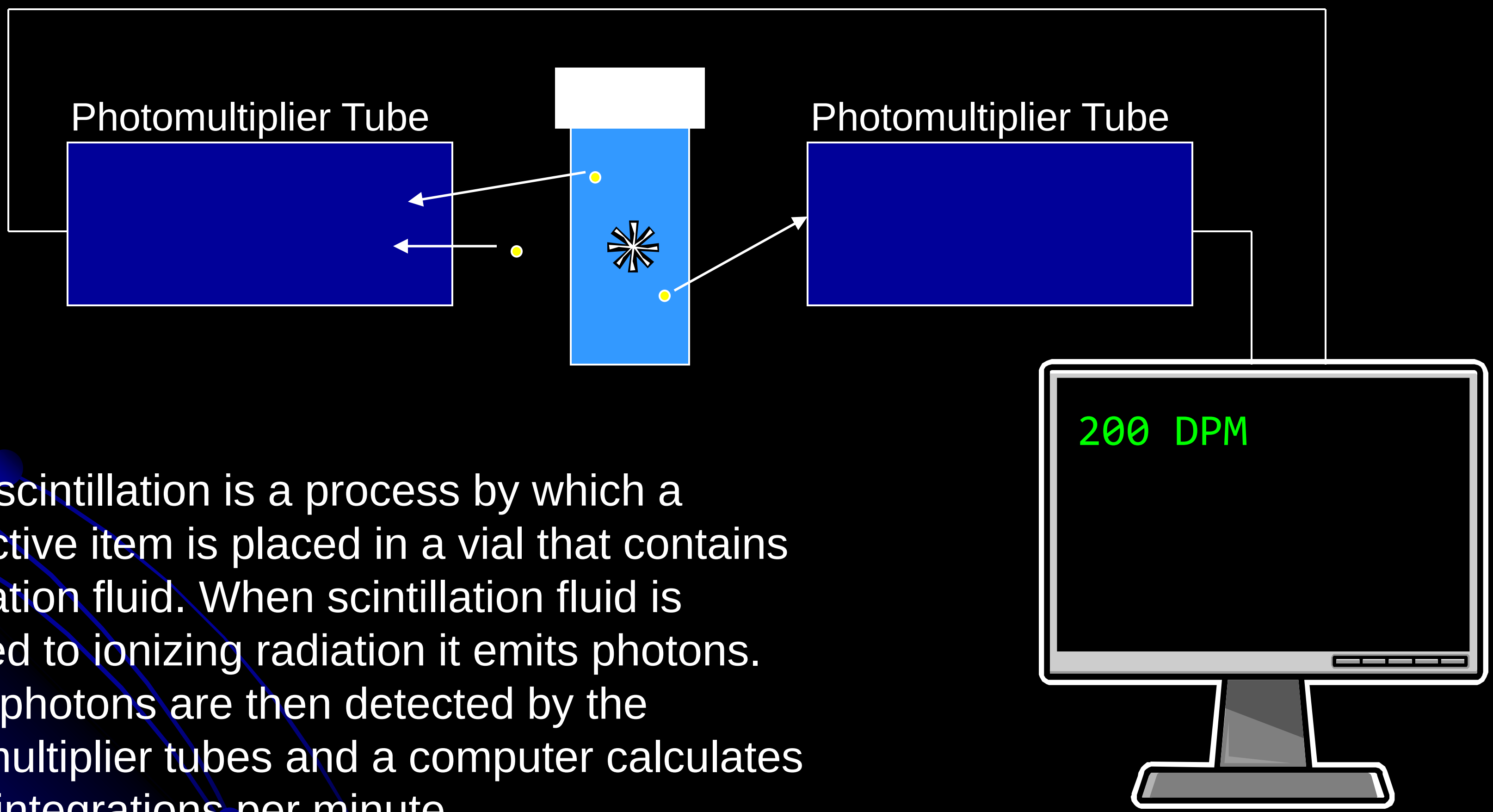
- Can't taste it.

Dosimetry

- Monitors exposure to radiation
- Must be worn when working with radioactive materials or in a radiation area
- Full body badge should be worn on the torso facing the same direction as wearer
- Ring badge is worn on the dominant hand, and the name faces towards the source
- NEVER Take it home
- NEVER Leave it in the car
- NEVER microwave your badge!

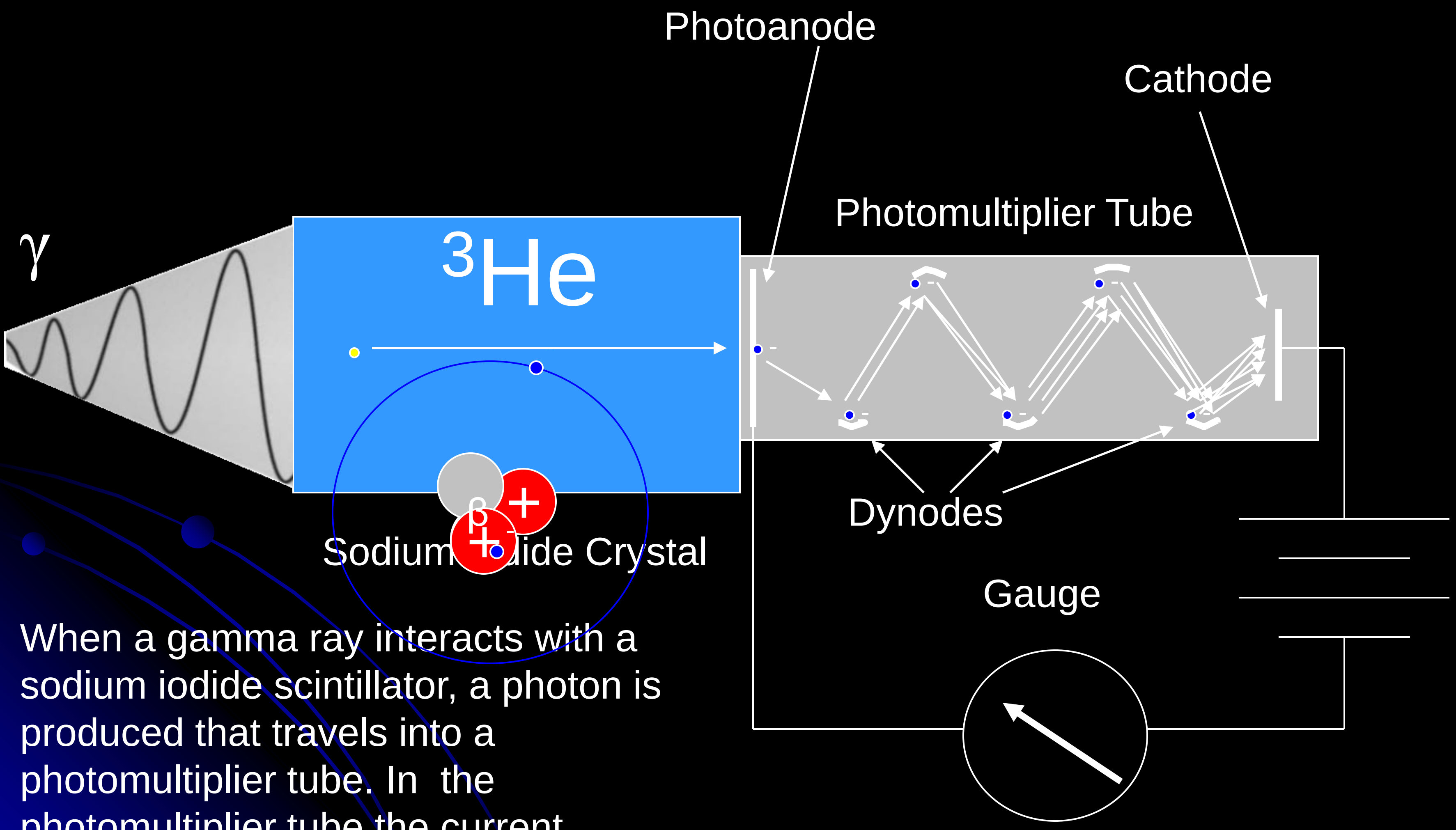


Liquid Scintillation



Liquid scintillation is a process by which a radioactive item is placed in a vial that contains scintillation fluid. When scintillation fluid is exposed to ionizing radiation it emits photons. These photons are then detected by the photomultiplier tubes and a computer calculates the disintegrations per minute.

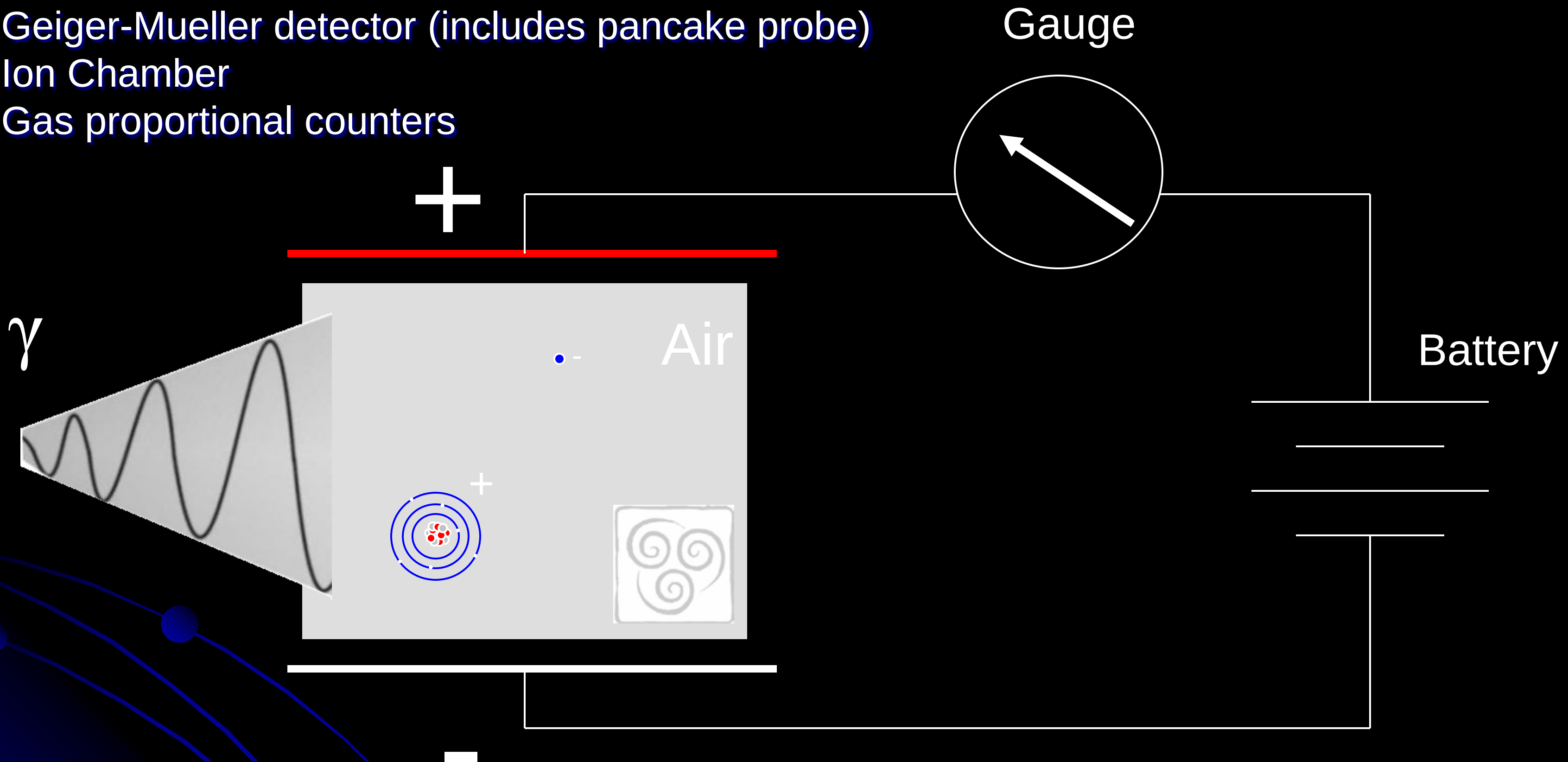
Sodium Iodide Scintillator



When a gamma ray interacts with a sodium iodide scintillator, a photon is produced that travels into a photomultiplier tube. In the photomultiplier tube the current produced by the photon is multiplied resulting in a deflection of the gauge.

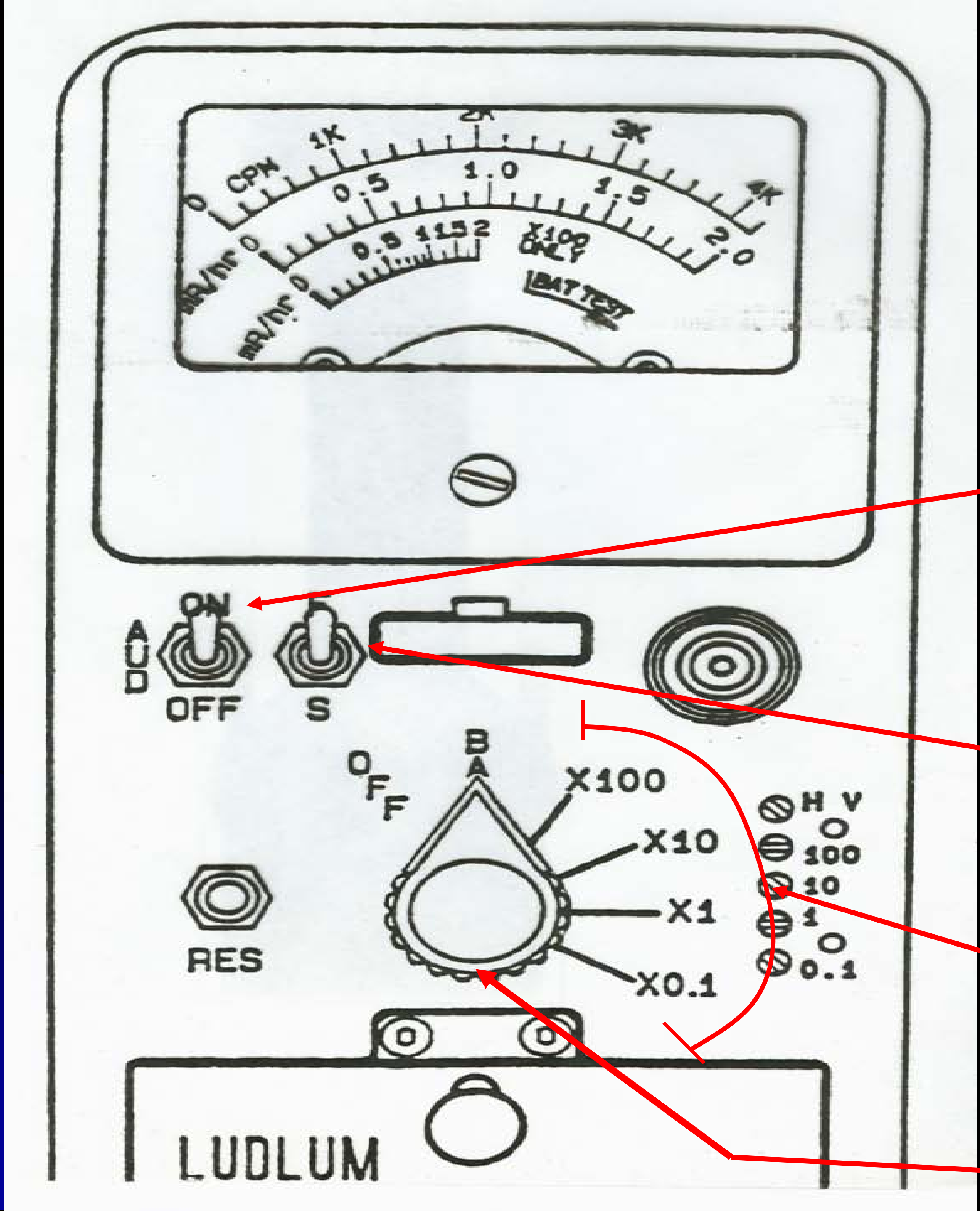
Ion Chambers

- Geiger-Mueller detector (includes pancake probe)
- Ion Chamber
- Gas proportional counters



In this type of detector ionizing radiation, like the gamma ray shown here, creates ions in the area between the cathode and anode. These ions allow for the completion of the circuit. The amount of electricity that flows tells us how much radiation is present.

The following slides will help you become familiar with reading survey meters. The one shown here is a Ludlum survey meter, but most function in a similar fashion.

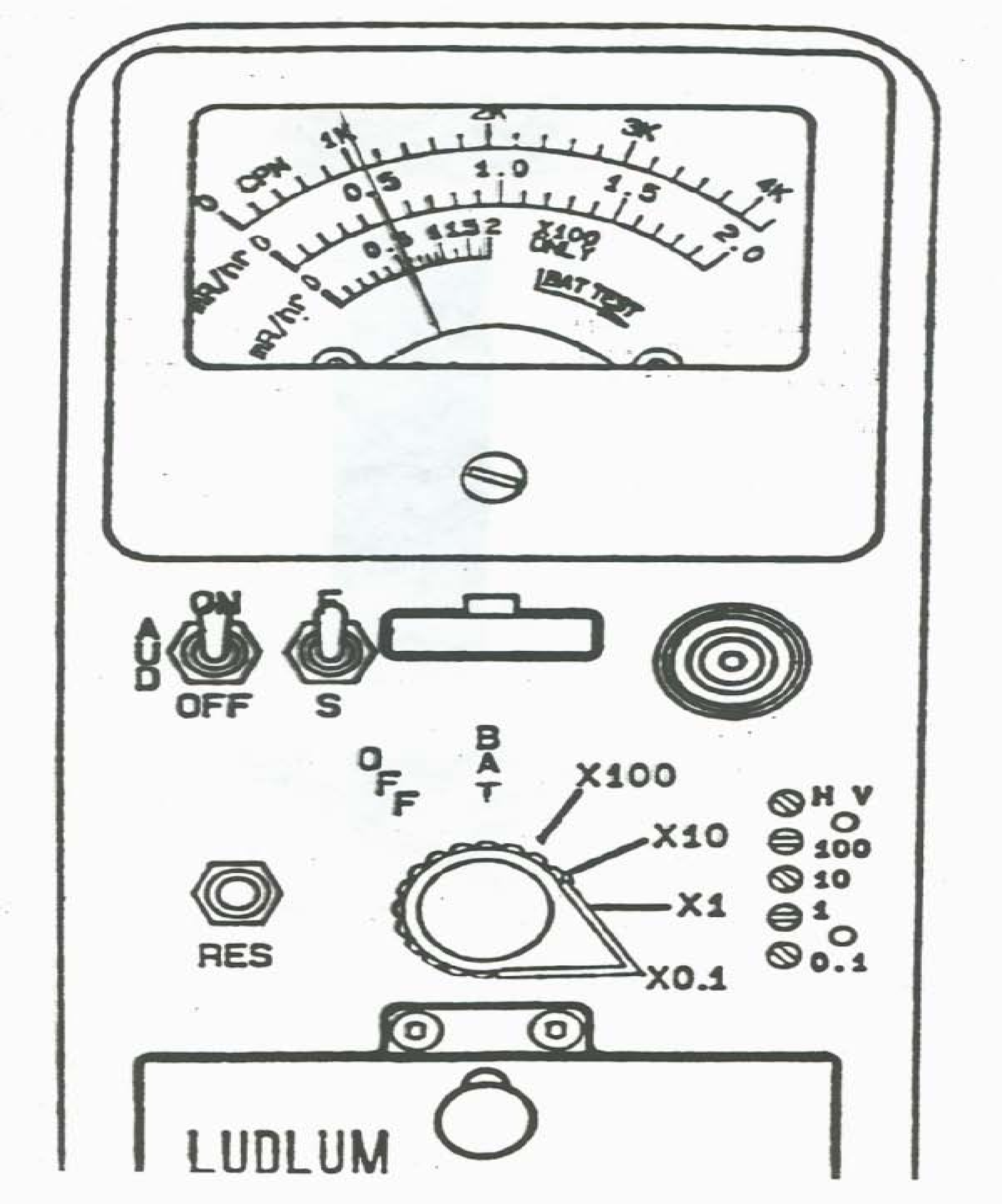


Audio on/off switch

Fast/Slow switch. For normal use set to F for fast.

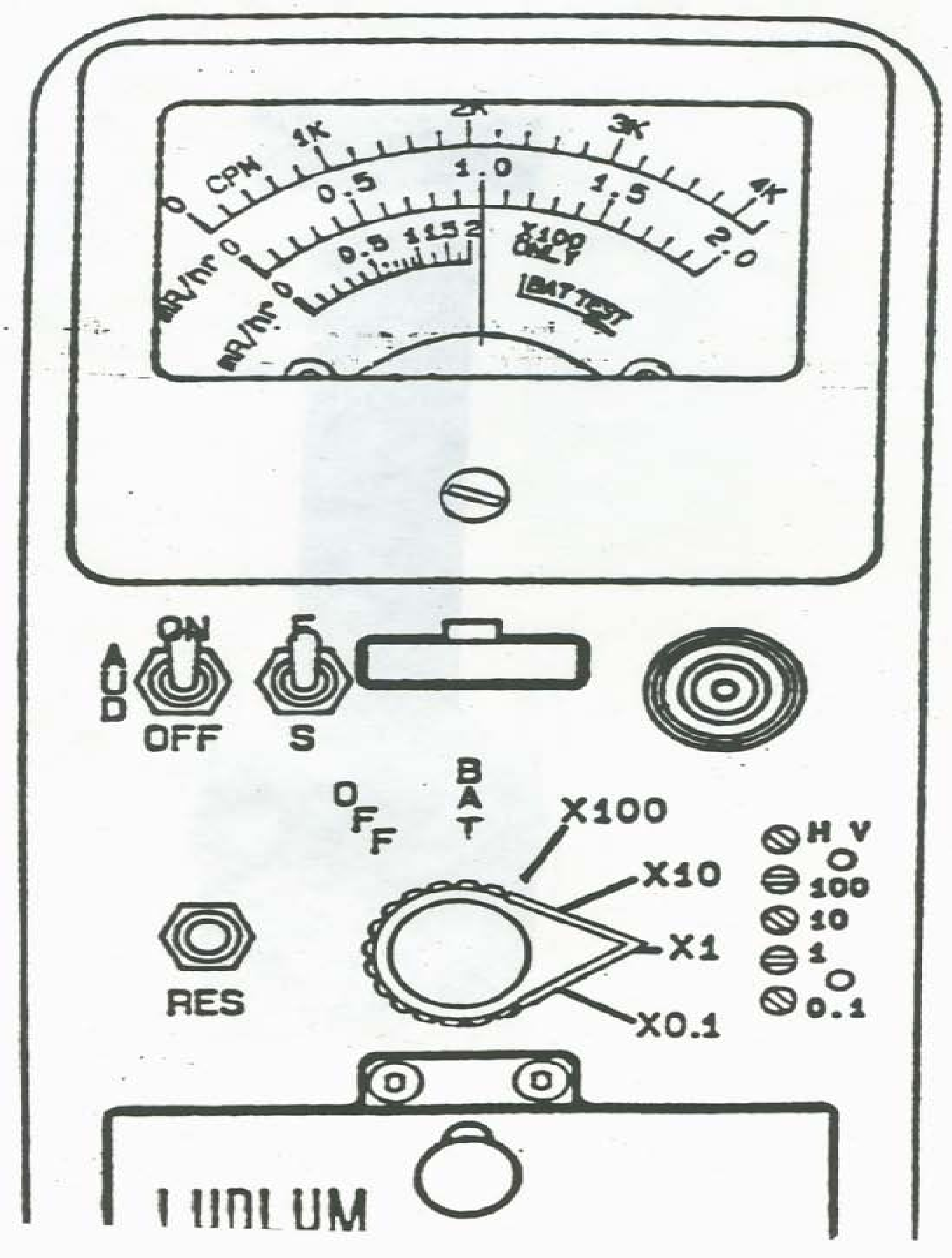
Multipliers

Range Selector Switch



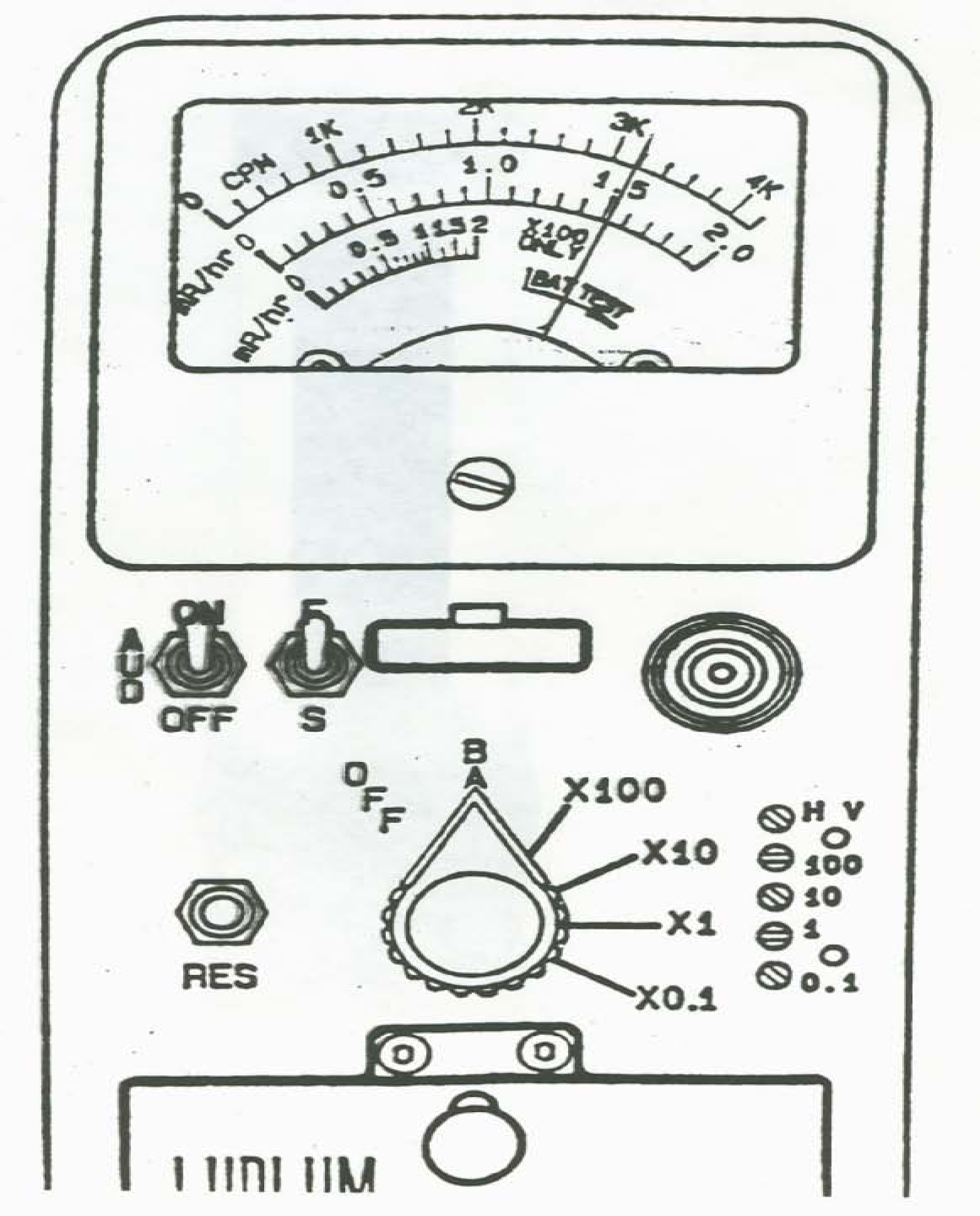
Since the range selector switch on this picture is set to X0.1 and the needle is deflected to approximately 1K this meter is displaying a reading of 100 CPM.

If the meter has been calibrated to detect exposure, then the MR/hr line should be read and this meter is displaying a reading of 0.05 MR/hr.



Since the range selector switch on this picture is set to X1 and the needle is deflected to approximately 2K this meter is displaying a reading of 2000 CPM.

If the meter has been calibrated to detect exposure, then the MR/hr line should be read and this meter is displaying a reading of 1.0 MR/hr.

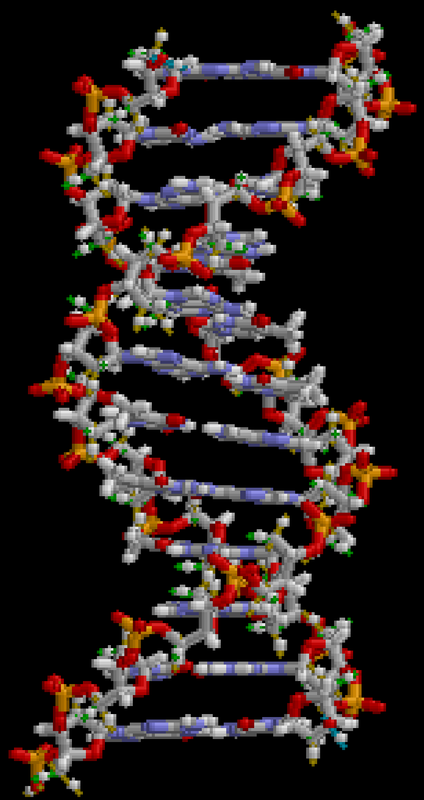


Since the range selector switch on this picture is set to “BAT”, the “BAT TEST” line should be read .This meter is indicating that the battery is sufficiently charged.

For this reason, it is critical to know where the range selector switch is set.

Biological Effects

- Ionizing Radiation can break molecular bonds which may result in damage to cellular structures and DNA



Mutation Video

Biological Effects Video

A dose of **10 mrem** creates a risk of death from cancer of approximately **1 in 1,000,000**.

Dose limits

- Whole body – 5 rem/year
- Organ/tissue – 50 rem/year
- Lens of the eye – 15 rem/year
- Skin and extremities – 50 rem/year
- Minors – 10% of above limits
- Fetus – 500 mrem over gestation period
- Member of the public – 100 mrem in one year

Pregnant Worker

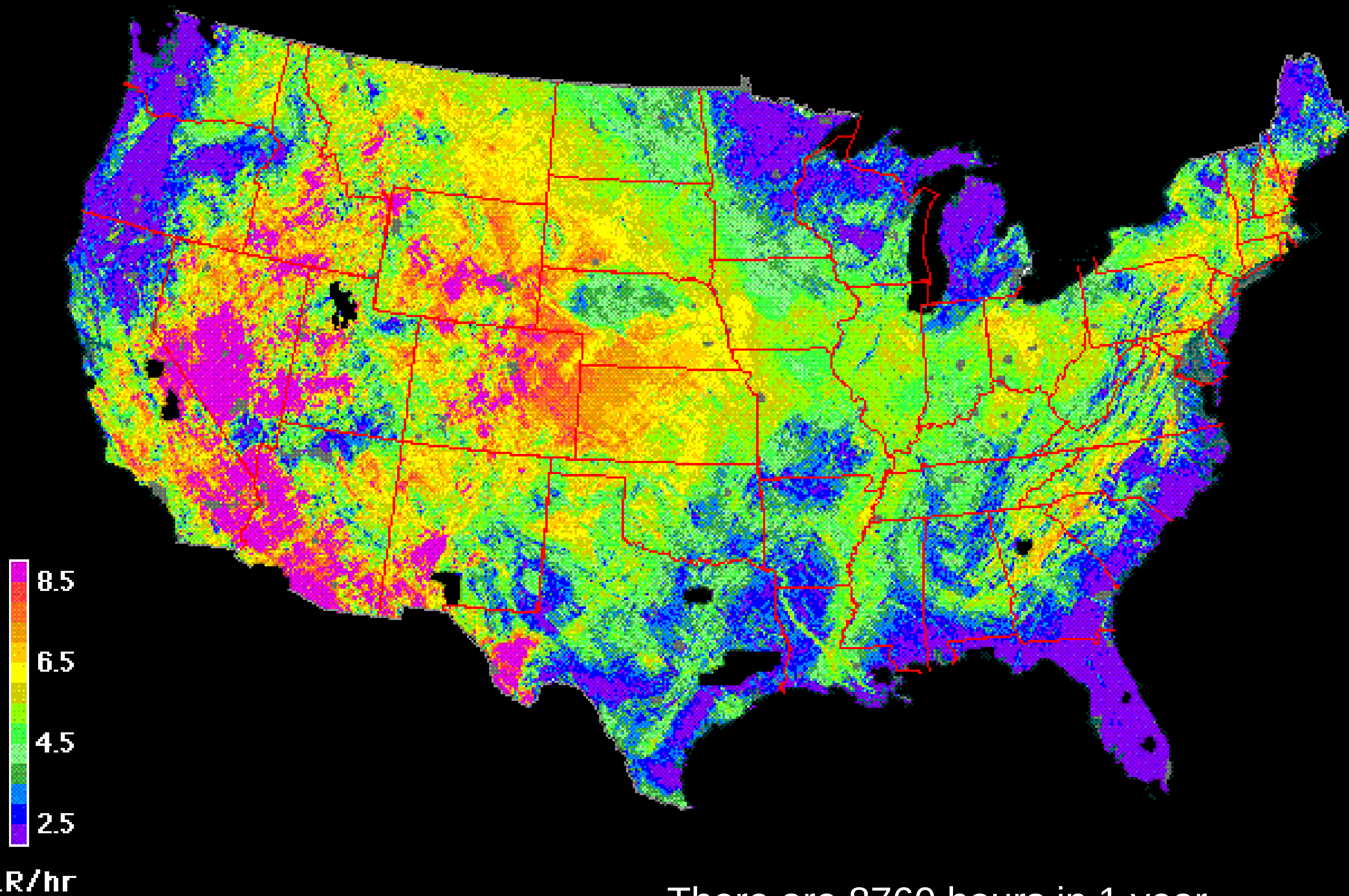
- Must declare in writing
- Monitoring begins from the estimated date of conception following the declaration of pregnancy
- Monitoring continues until worker withdraws declaration (in writing), or for 12 months.

Declaration of Pregnancy Form

A.L.A.R.A.

- As Low As Reasonably Achievable
- Operating Philosophy required by regulation, but…
- Not a regulatory level
- Dose limits still apply, but aim for much less.

Terrestrial Gamma-Ray Exposure at 1m above ground



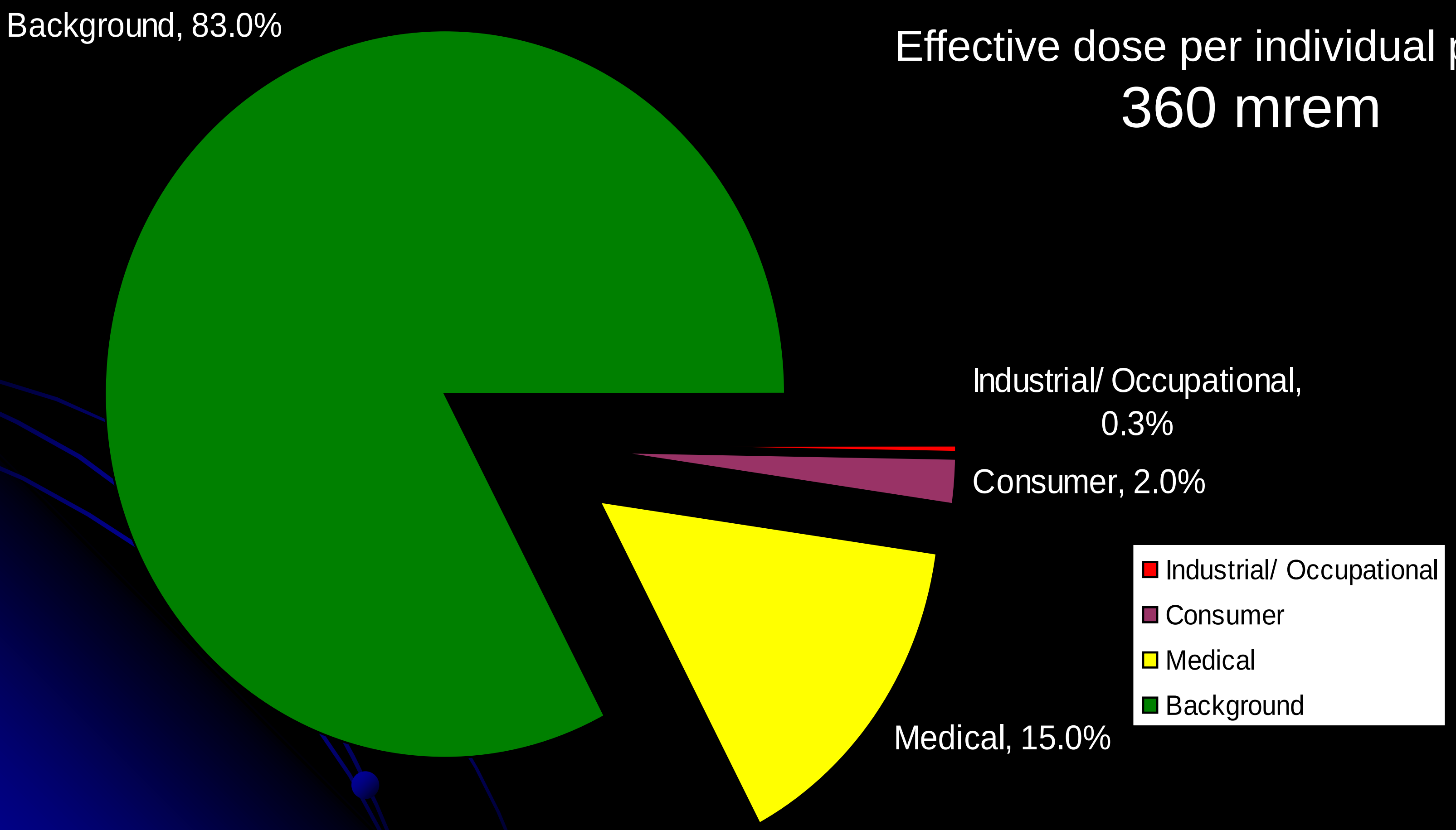
There are 8760 hours in 1 year

Source of data: U.S. Geological Survey Digital Data Series DDS-9, 1993

NCRP Report on Exposure to the Population of the United States

1980

Effective dose per individual per year
360 mrem

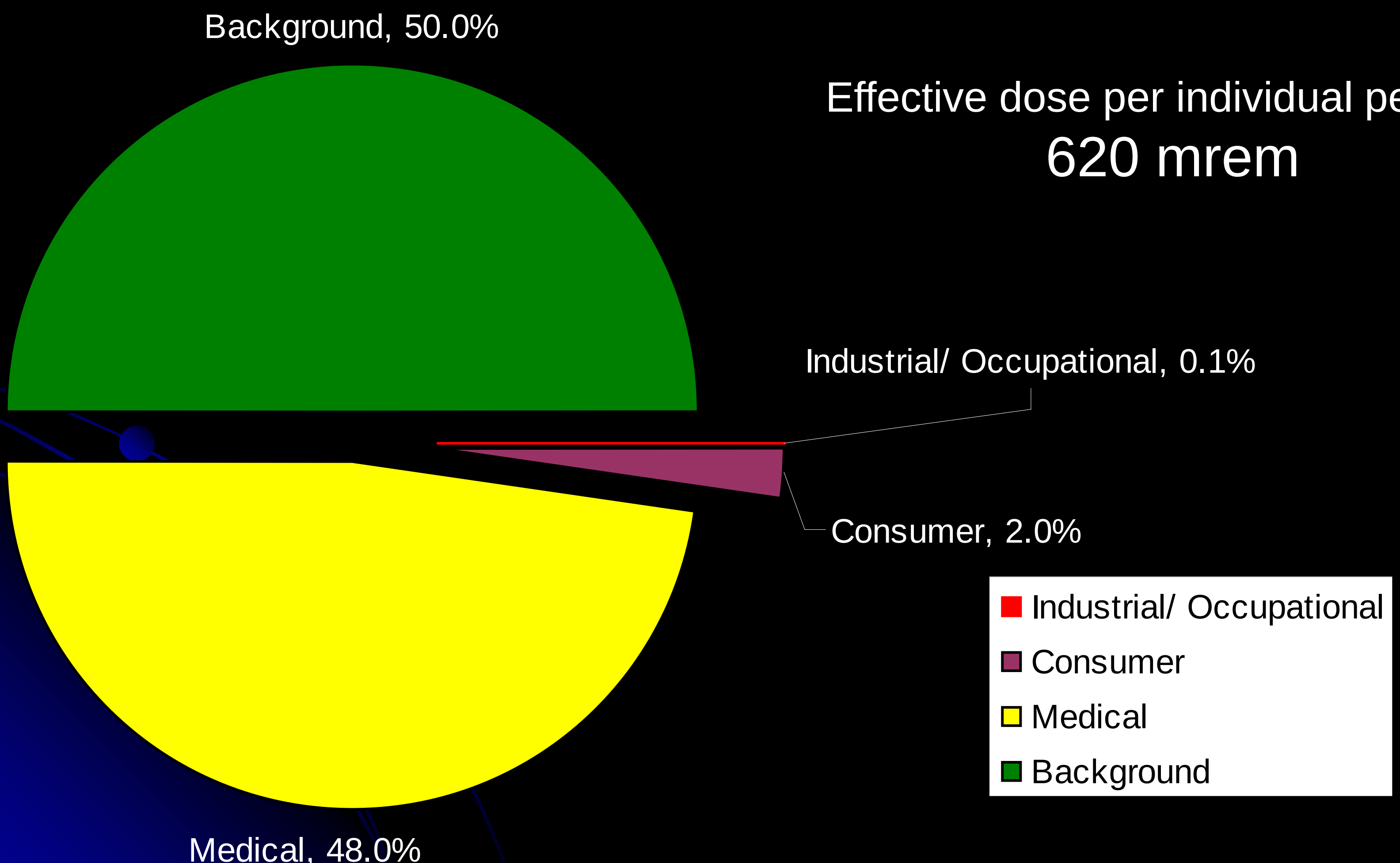


NCRP Report on Exposure to the Population of the United States

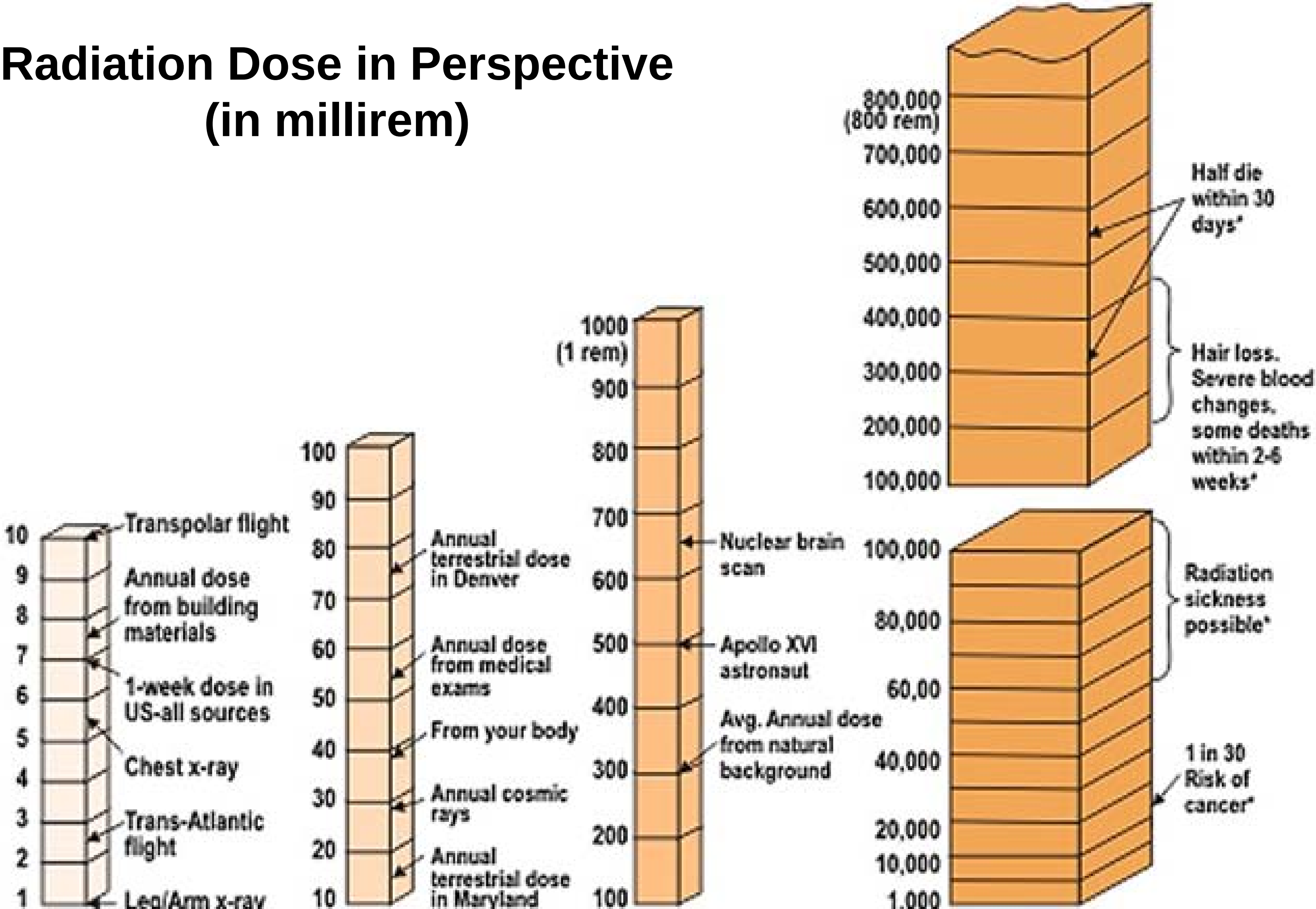
2006

Effective dose per individual per year

620 mrem



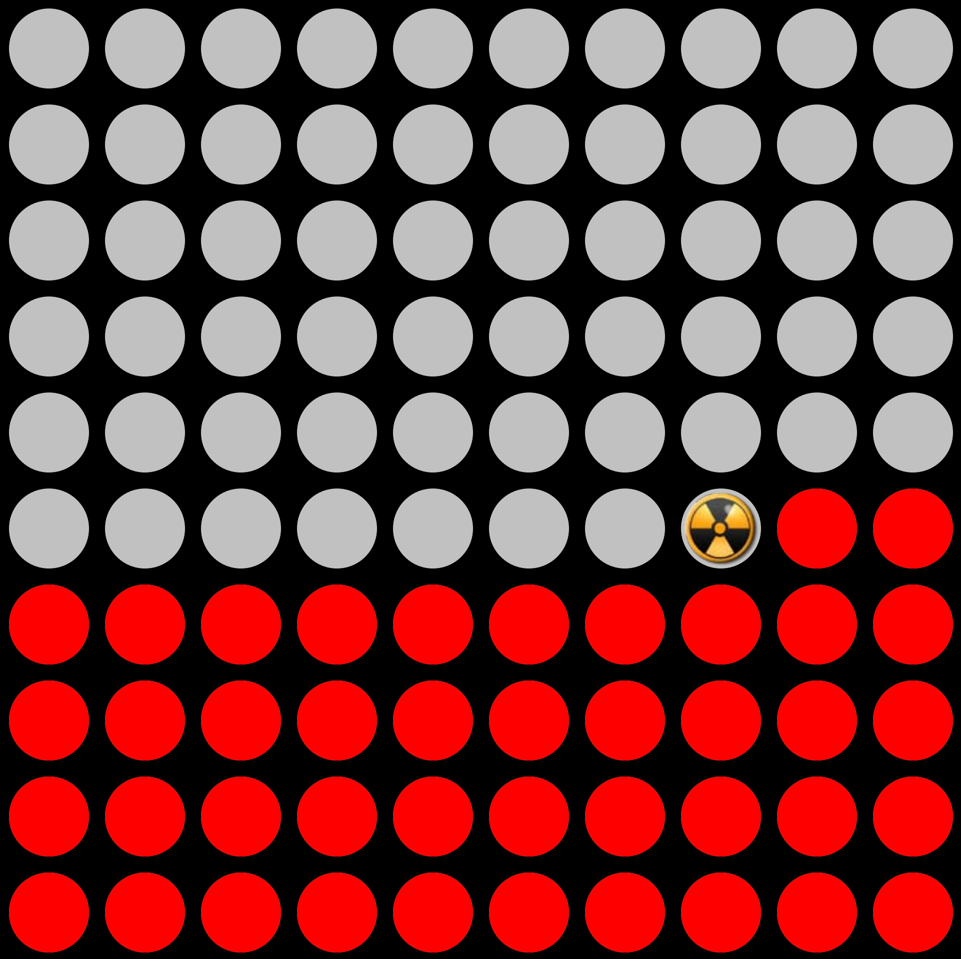
Radiation Dose in Perspective
(in millirem)



* Doses received over short time period (hours to days) at high dose rates are "acute" doses.

Cancer

- If 100 people were exposed to **10 rem,** approximately **1 in 100** would develop cancer.
- About 42 out of 100 people will be diagnosed with cancer from causes unrelated to radiation in their lifetimes.
- The risk of developing cancer increases from 42% to 43% after an exposure of 10 rem



*As reported by The National Academies BEIR VII Report

Contamination vs. Exposure

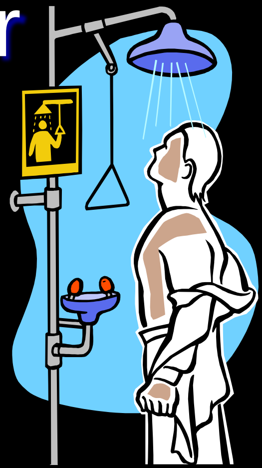
Video

Contamination Detection: Frisking

- Start with your hands. Look for contamination just as you would during a survey – slowly and at 1 cm from the surface
- Check your hands, arms, body, and soles of your shoes
- If contamination is found remove contaminated clothing (i.e Lab coat, gloves, shoes, etc.)
- Use Radiacwash Towelettes for minor skin contamination.

Skin Contamination

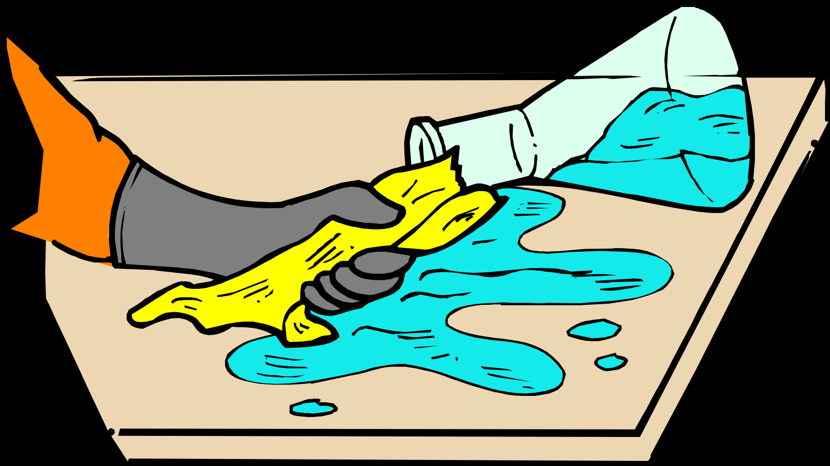
- **Deal with severe injuries first!**
- Measure level of activity with survey meter
- Remove contaminated clothing
  - Contaminated clothing is radioactive waste
- Use Radiacwash Towelettes or…
- Wash with mild soap in lukewarm water
- Avoid abrading the skin



Spills

Clean-Up Procedures:

- Warn others
- Contain the spill
- Contact the RSO
- Follow RSO's directions
- RSO will:
  - Survey area after clean-up
  - Decontaminate area and equipment if necessary
- All clean up materials are radioactive waste
- Dispose wastes (through the RM/EHS Office Ext. 3-3531)
- Always use PPE when cleaning-up a spill



Contact RM/EHS for Clean-Up of **ANY** Radioactive Materials Spills

at Ext. 3-3531 (Off-Hours 3-3700)

Emergencies

- Call 911
  - Campus Phone – University police
  - Cell Phone – California Highway Patrol
- Identify yourself
- Give information:
  - Nature and severity of the Emergency
    - Let first responders know that radioactive material is involved
  - Location
- CHP can connect you to campus police
- Notify RSO of any emergencies that involve radioactive material

Injuries

Deal With Severe Injuries Immediately!

For minor injuries decontaminate first

First Aid – Student Health Center

- All Emergencies – Call 911
    - Public safety will arrange for transportation to the appropriate medical facility
- Report injuries:
    - To Immediate supervisor and to…
        - As soon as possible after getting medical attention
    - Worker's Compensation Office
        - State Employees
            - Denise Watson-Cross, Workers Compensation Coordinator
                - 3-3657
        - UAS Employees
            - Dorothy Wu Payroll & accounting Benefits manager
                - 3-2533

Emergency Response

- For full details on emergency response:

EMERGENCY RESPONSE PROCEDURES FOR EVENTS INVOLVING RADIOACTIVE MATERIAL

Radioactive Material License

- CSULA has a broad-scope, type B license.
  - We can authorize usage on campus of most any isotope within the limits stated on our license.
- License is administered by the RSO with oversight from the RSC
- License issued by the California Department of Public Health

If you would like to see a copy of CSULA's license call 3-3546

Authorization

- Authorization
  - specifies approved isotopes and activities
  - Lists authorized and designated users
  - List authorized locations
- Must be renewed annually

To apply for an authorization submit Application Form 1 and Form 2 to the RSO.

Authorization

- Must be approved by the RSO and authorized by the RSC
- Tell us what you're using, how you're using it and where you are using it.
- Authorization is required before RAM can be purchased or used/possessed on campus.

To apply for an authorization submit Application Form 1 and Form 2 to the RSO.

Authorized Users

- Must complete a training and experience form
- Must be trained annually
- Are responsible for following safety procedures when working with RAM

Designated Users

- Must work under the Supervision of an Authorized User
- Must be trained annually
- Must submit a training and experience form

Training & Experience Form

California State University, Los Angeles | EH&S / Radiation Safety

STATEMENT OF TRAINING AND EXPERIENCE

1. Identification:

Name:		CSULA ID#:
D.O.B:	Phone:	Email:
Department / Facility Name:		
Title:		

2. Location of Use:

Principal Investigator/Authorized User:	
Building:	Room Number(s):

3. Training / Education:

a) High school graduate (Mark with an X): Yes: No:

b) College or University:

Name:
Location:
Course of study:
Degree:
Year completed:

c) Education or training specifically applicable to the use of radioactive material or radiation producing machines:

I completed CSULA's initial radiation safety training requirements on
___/___/___ and will complete refresher training annually.

4. Experience

a) List experience with radioactive material or radiation producing machines, beginning with the most recent.

______________________________ ____________

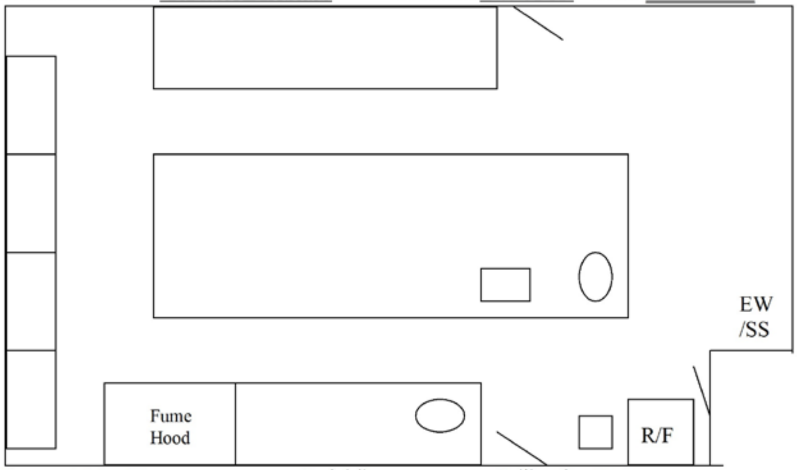
Signature Date

Surveys and Wipes

- Each Lab must be surveyed and documented monthly
- Detector should be moved slowly at about 1 centimeter above the surface.
- Don’t contaminate the meter
- A survey meter is sufficient for S-35 don’t need to wipe
- Tritium cannot be detected by a Pancake probe. Use Liquid Scintillation
- Survey in areas that are likely to be contaminated.
- How many spots should be surveyed? More is better, but usually around 15 or more depending on the size of the lab.

Radioactive Materials Authorized Location
Quarterly Survey and Wipe Test

Authorized User: Dr. Russo-Neustadt Location: LKH 211 Date: __________



Survey Meter Type: __________ Serial #: __________ Calibration Date: __________
LSC Model#: __________ LSC Serial #: __________ Service Date: __________

RESULTS

Area	Survey Meter (cpm)	LSC (dpm) 0.0 - 2000 [1]	Notes:
BKG			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

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1. Energy values are in KeV

Surveys and Wipes

- **200 dpm per 100cm^2** or higher needs to be decontaminated
- Call RSO for assistance

Sealed sources

- MUST be leak tested every 6 months
  - If > 100 μCi for β & γ emitters
  - If > 10 μCi for α emitters
- Must be inventoried every 6 months

X-rays

- Never defeat interlocks
- Light indicates when x-rays are being generated
- Built to be inherently safe
- State regulated

Waste Disposal

- Picked up by EH&S Staff
- AU/DU must specify the isotope and activity
- Material is held for at least 10 half-lives for isotopes with a half-life of less than 120 days
- Longer lived isotopes must be sent to a licensed disposal facility

Radioactive Waste Tracking Form

Instructions: Complete one "form" for each waste container before removing waste from point of generation. Shaded areas for Radiation Safety only.

PI/Waste Generator: ________________________ BLDG:___________ Rm#:________

Radioactive Waste Tracking Number: ___________________--________

General description of waste (check appropriate item):

	Aqueous Liquid		Thorium Nitrate
	Organic Liquid (Mixed Waste)		Sealed Source
	Dry-Solid		LSC Cocktail T ½ > 90days, w/ <0.5uCi/ml
	Sharps		LSC Cocktail T ½ > 90days, w/ >0.5uCi/ml
	Carcasses / Animal waste		LSC Cocktail T ½ < 90 days
	Biological Material		Stock Vial
	Uranium Acetate		Contaminated equipment/device
	Uranium Nitrate		OTHER:

Profile of waste:

Radioactive Material		Hazardous / Biological Material		Exterior survey at pick-up		
Isotope	Act. (mCi)	Type/chemical	Quantity (ml,gm,)	CPM	Date	Initial

Quantity:

Total Quantity of Waste:	(ml, liters, ft^3, grams, etc.)
Quantity LSC in Vials:	# of vials: ______ Quantity of LSC/vial:______ml, Total ml:_____

Radiation Safety QA/QC

Name of person performing pick-up		
Name of person supplying waste profile information		
Instrumentation used for survey	☐ Thin window GM	☐ NaI
Model Number:		
Serial Number:		
Calibration date:		

Disposition

Date of pick-up	Date:
Transfer to satellite/interim storage area	Date: Location:
Transfer to long term storage facility	Date: Location:
Hold for decay: Y / N	Estimated date of decay:
Disposal Method:	☐Contract ☐Decay and release
Final survey and release (decay waste only)	Date: By:
Date of packaging for contract disposal	Date: By:
Date of contract disposal	Date: By:

Radiation Safety Officer:____

To dispose of Rad-waste: Call EH&S at 323-343-3531

Know your Isotope

P32 H3 Am241 I125

C14 S35 Cs137

U238 Po210

Co60

^3H

Tritium

- Half-Life: 12.35 yrs
- β emitter: 18.6 keV
- Annual Limit on Intake (ALI): 80 mCi
- Biological Half-life: 12 days
- Effective Half-life: 12 days
- Shielding: none recommended
- Detection:
  - Liquid Scintillation Counter (LSC)
  - Thin-Window GM will not detect

^{14}C

Carbon-14

- Half-Life: 5730 yrs
- β emitter: 156 keV
- Annual Limit on Intake (ALI): 2 mCi
- Biological Half-life: 10 days
- Effective Half-life: 10 days
- Shielding: none recommended
- Detection:
  - Liquid Scintillation Counter (LSC)
  - Thin-Window GM (~5% efficiency)

^{35}S

Sulfur-35

- Half-Life – 87.39 days
- β emitter - 167.47 keV
- ALI – 8 mCi (Ingested); 10 mCi (Inhalation)
- Biological Half-life – 90 days
- Effective Half-life – 44.3 days
- Shielding: Acrylic recommended
- Detection:
  - Liquid Scintillation Counter (LSC)
  - Thin-Window GM (~10% efficiency)

^{60}Co

Cobalt-60

- Half-Life: 5.27 yrs
- β and γ emitter: 2.824 MeV β;
  - 1.17 & 1.13 MeV γ

Annual Limit on Intake (ALI): 54 μCi

- Biological Half-life: 9.5 days
- Effective Half-life: 9.5 days
- Shielding: acrylic inner, lead outer
- Detection: Thin-Window GM
  - ~15% **β** efficiency; 0.56% γ efficiency

^{137}Cs

Cesium-137

- Half-Life: 30.07 yrs
- β emitter: 1.176 MeV
  - 2.5 MeV γ from decay of Barium-137m (2.5 min half-life)
- ALI:100 μCi (Ingested); 200 μCi (Inhalation)
- Biological Half-life: 70 days
- Effective Half-life: 70 days
- Shielding: acrylic inner, lead outer
- Detection:
  - Thin-Window GM
    - ~15% **β** efficiency
    - 0.42% γ efficiency

How Do We Protect Ourselves?

- Laboratory Procedures
  - Contamination Control Video
- Personal Protective Equipment
- Time
- Distance
- Shielding

Personal Protective Equipment

- Safety Goggles
- Gloves
- Lab Coat
- Proper Attire
  - No Open Toed Shoes

Normal laboratory PPE will only help you avoid contamination. To minimize exposure follow the advice on the next 4 slides.

Time

- Less time around a source of radiation results in a lower exposure.
  - Important because health effects are cumulative

Distance

- Inverse square law
  - Double the distance and get ¼ dose

$$I_1(d_1)^2 = I_2(d_2)^2$$

$$I_2 = \frac{I_1(d_1)^2}{(d_2)^2}$$

Where:

I_1= intensity at position 1

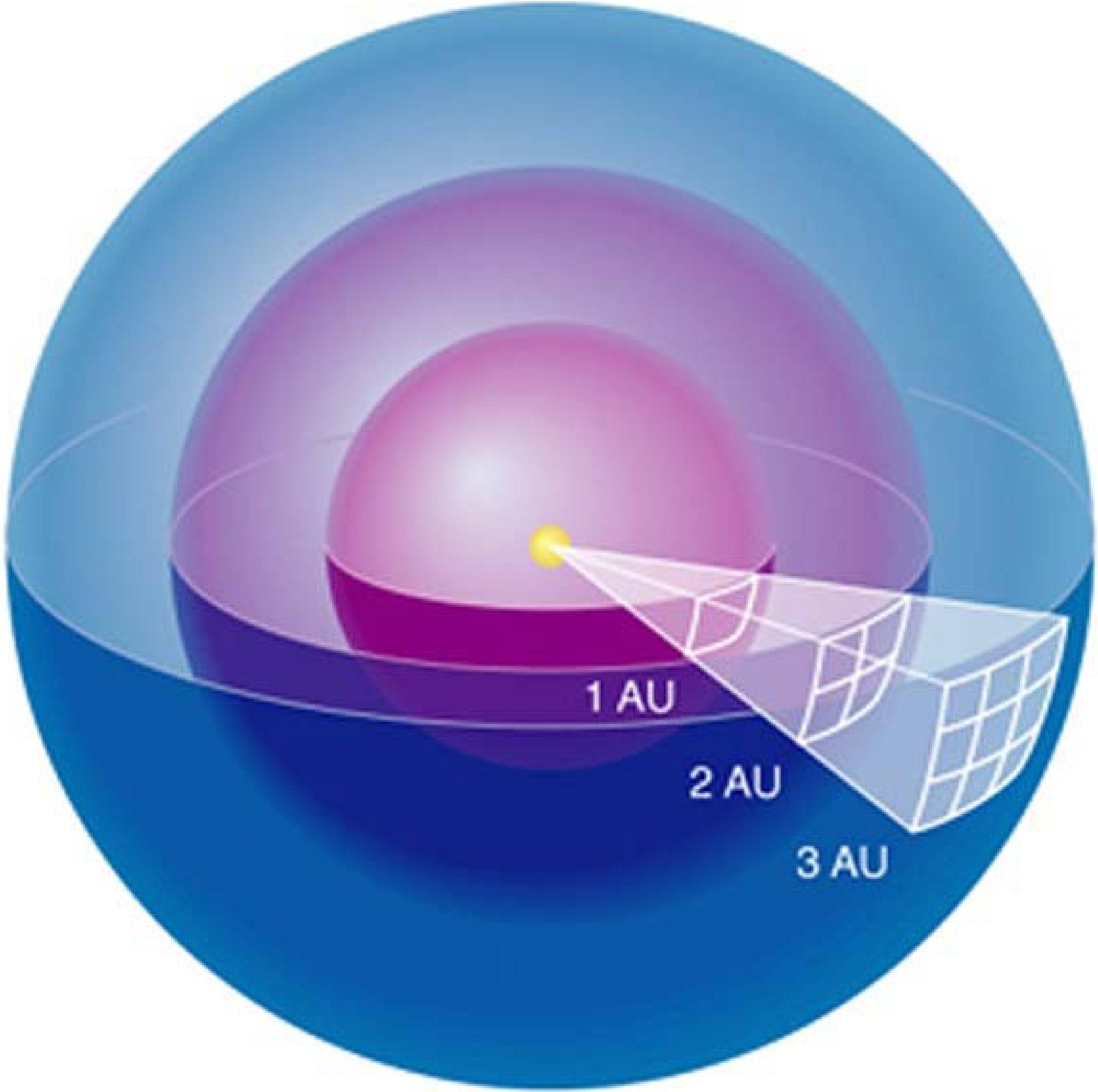
I_2 = intensity at position 2

d_1 = *distance* from source to position 1

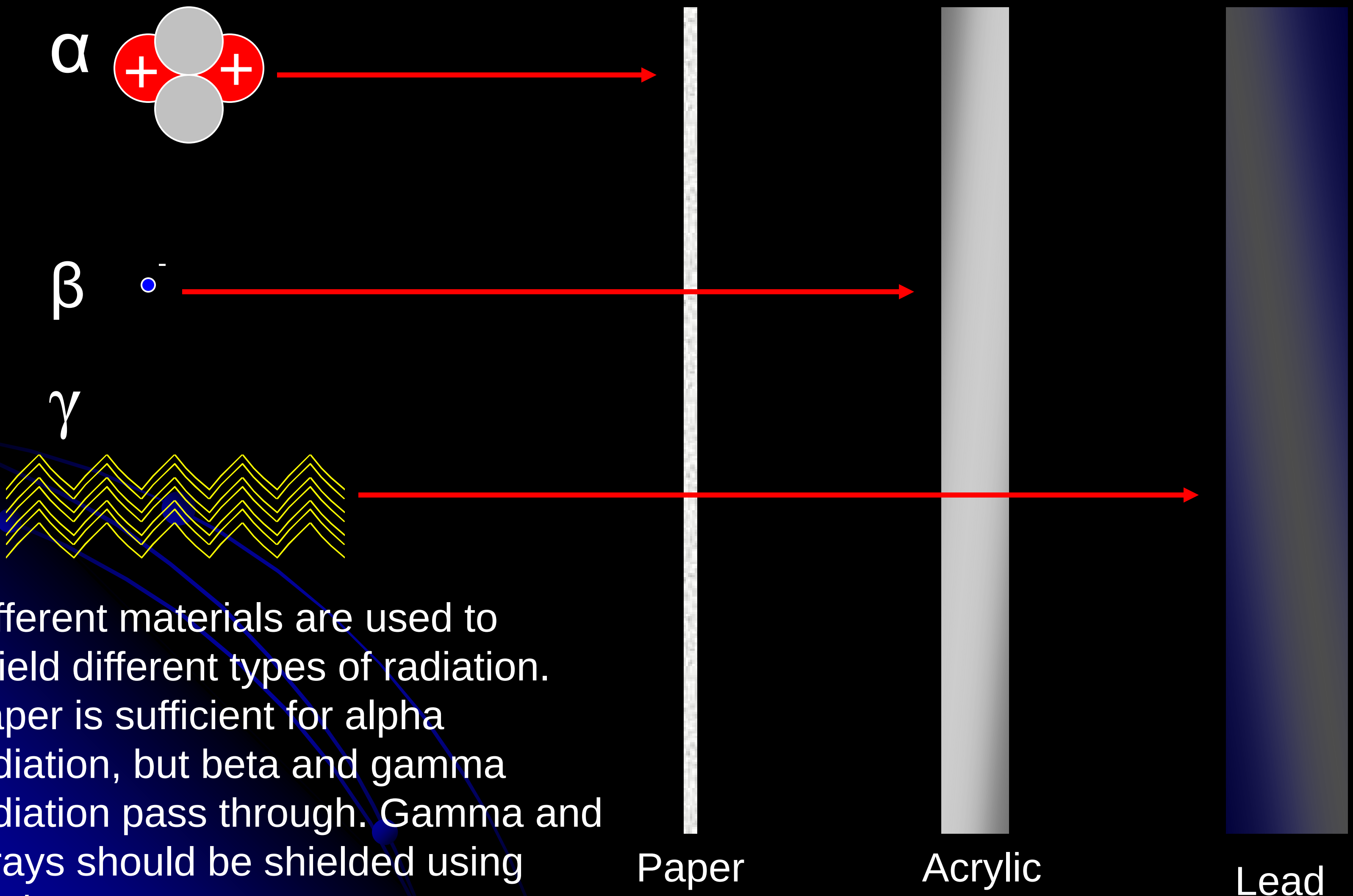
d_2 = *distance* from source to position 2

Inverse Square Law

Double the distance get 1\4th of the dose.



Shielding



Different materials are used to shield different types of radiation. Paper is sufficient for alpha radiation, but beta and gamma radiation pass through. Gamma and x-rays should be shielded using lead.

Any Questions?

If you learned nothing else:

- TIME
- DISTANCE
- SHEILDING

Can lower your exposure to radiation