What students oughtta know before attending university . . .

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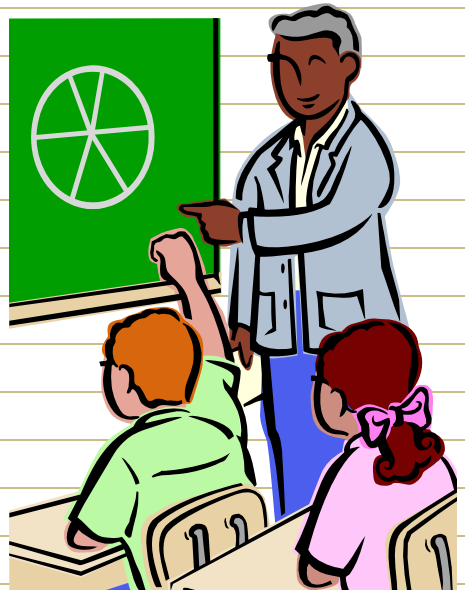
National Physics Teachers' Workshop
15 July, 2011

Who I am

- Former teacher of high school chemistry, physics and math
- Current teacher of university nuclear science and engineering



What new university students should know about nuclear science and engineering?

It is SO much more than

nuclear power and nuclear engineering

Nuclear Technology Affects Us All

Within the last week did you…

_____ Ride in a car/bus
_____ Sit or stand next to someone for more than a few minutes
_____ Walk or drive on a road
_____ Use electricity
_____ Use anything made with petroleum (oil)
_____ Use a sheet of paper or Aluminum Foil
_____ Use cosmetics (make-up) or eye drops
_____ Take any type of medication
_____ Use plastic wrap
_____ Watch TV or a computer monitor
_____ Stay in a room or building with a smoke detector
_____ Use a non-stick frying pan
_____ Use any appliance or device with a computer (control/monitor)
_____ Use a medical bandage (Band-Aid®)

In the last week have you consumed…

_____ Ice Cream
_____ Eggs
_____ Rice
_____ Brazil Nuts[-]
_____ Wheat/flour
_____ Applesauce
_____ Banana[+]
_____ Soda (pop)

In the last year have you…

_____ Traveled across a metal bridge
_____ Visited a museum
_____ Had an x-ray or CT scan taken
_____ Used a photocopy machine
_____ Been around someone who smokes

Nuclear Technology Affects Us All

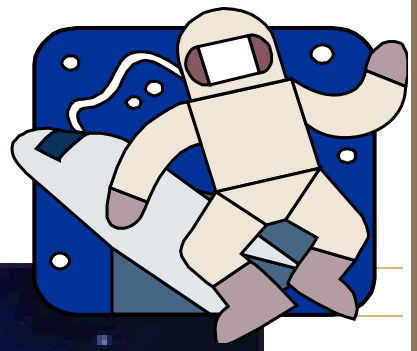
In your lifetime have you…

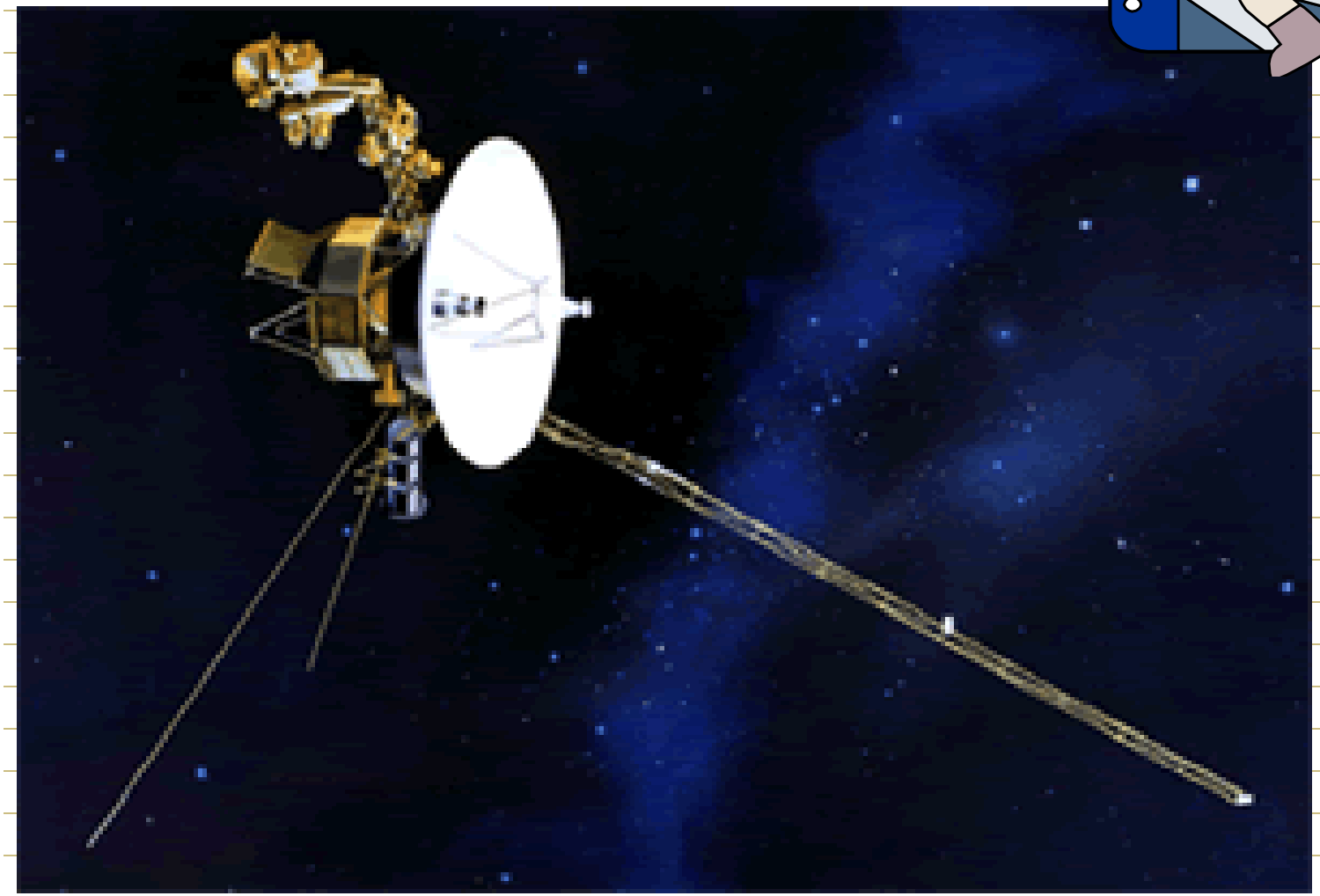
_____ Seen a white or pink poinsettia
_____ Seen blue topaz
_____ Been in a hospital
_____ Been on an airplane
_____ Seen pictures of Jupiter, Mars, or Saturn
_____ Seen the Statue of Liberty or the Liberty Bell
_____ Learned about Photosynthesis
_____ Played in the dirt
_____ Licked a postage stamp
_____ Taken a picture (with film)
_____ Known anyone who has had brain surgery with the Gamma Knife
_____ Known anyone who has given blood or had a special blood test
_____ Known anyone who had a stress test or heart catheterization
_____ Known anyone who has been treated for cancer
_____ Known anyone who has been treated for a thyroid disorder

Medicine

- Diagnosis
- Treatment
- Sterilization

Space exploration





Industry

- Thickness gauging (aluminum sheets, paper, egg shells)
- Material treatment (polymerization)
- Sterilization (baby formula, medical supplies, contact lens solution)
- Materials testing (structural integrity, weld quality, faults/impurities)
- Food irradiation

Agriculture

- Irradiation of food to
  - Slow ripening
  - Kill germs that cause rotting and disease
  - Sterilize
- Irradiation of harmful insects to decrease population
- Irradiation of seeds/tubers/bulbs to create new varieties

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But what does a nuclear scientist or engineer DO?

Freshman introduction to engineering

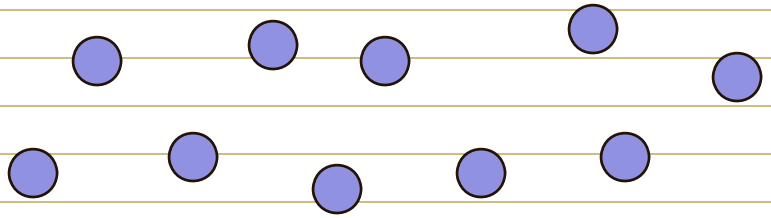
What is Radiation?

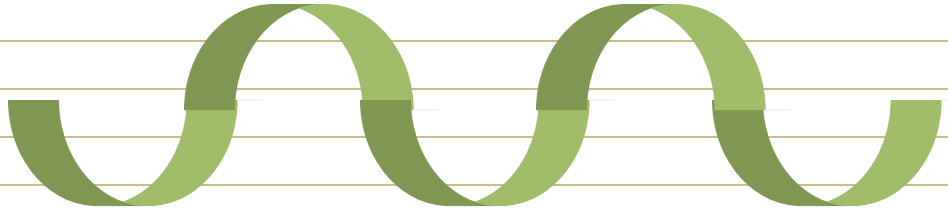
Transmission of energy via . . .

Particles

or

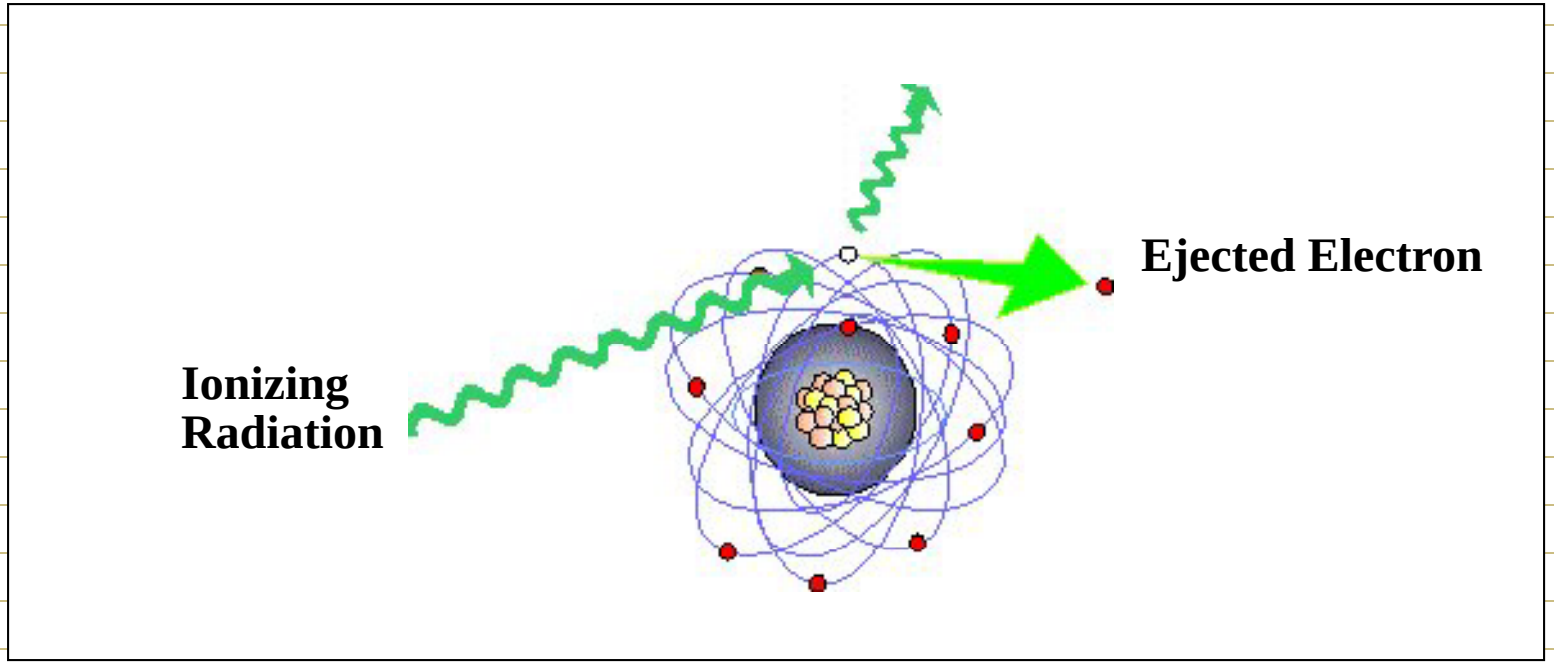
Waves





Why is it called *ion*izing?

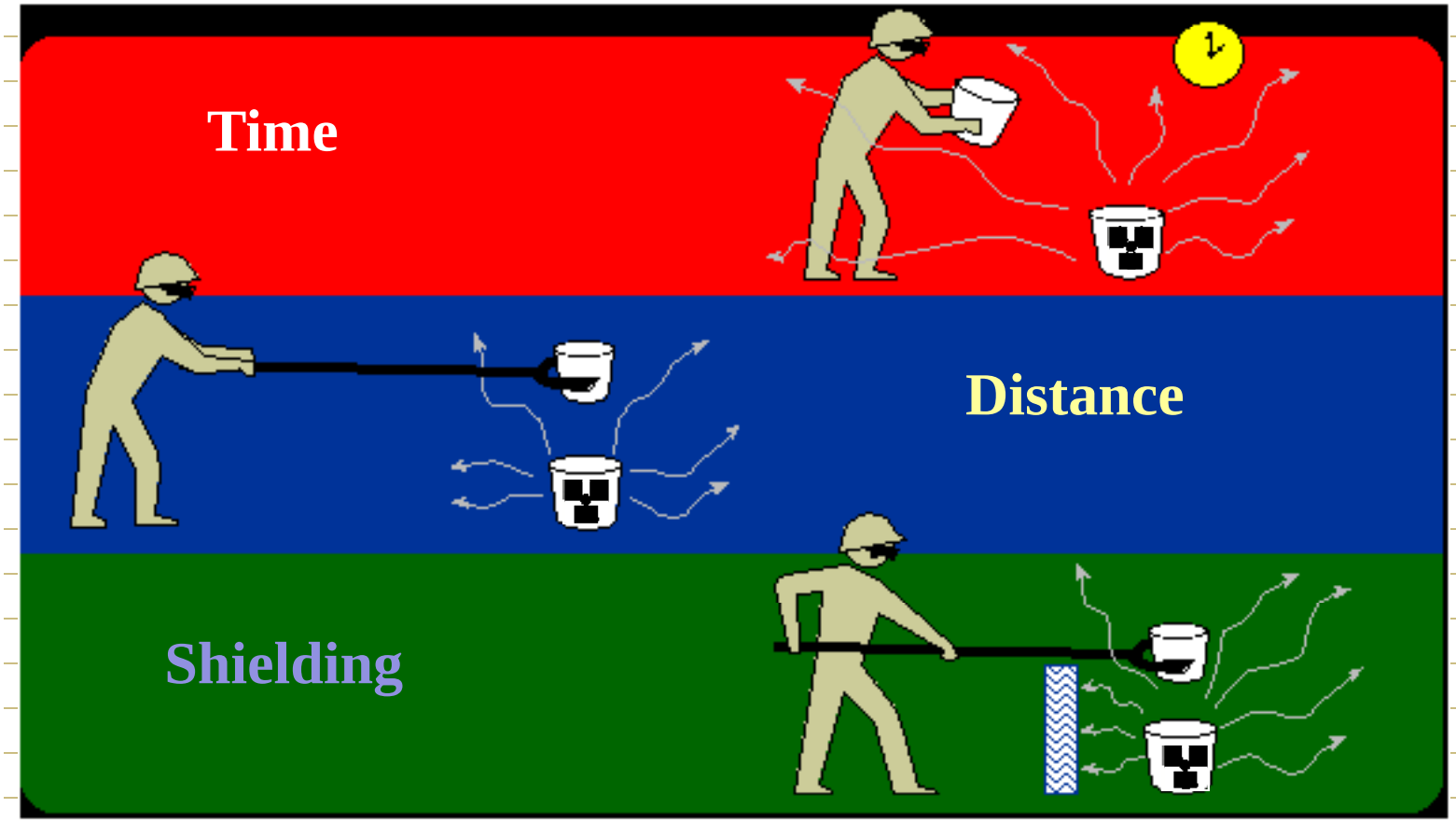
Because it creates *ions* -- atoms with a charge.



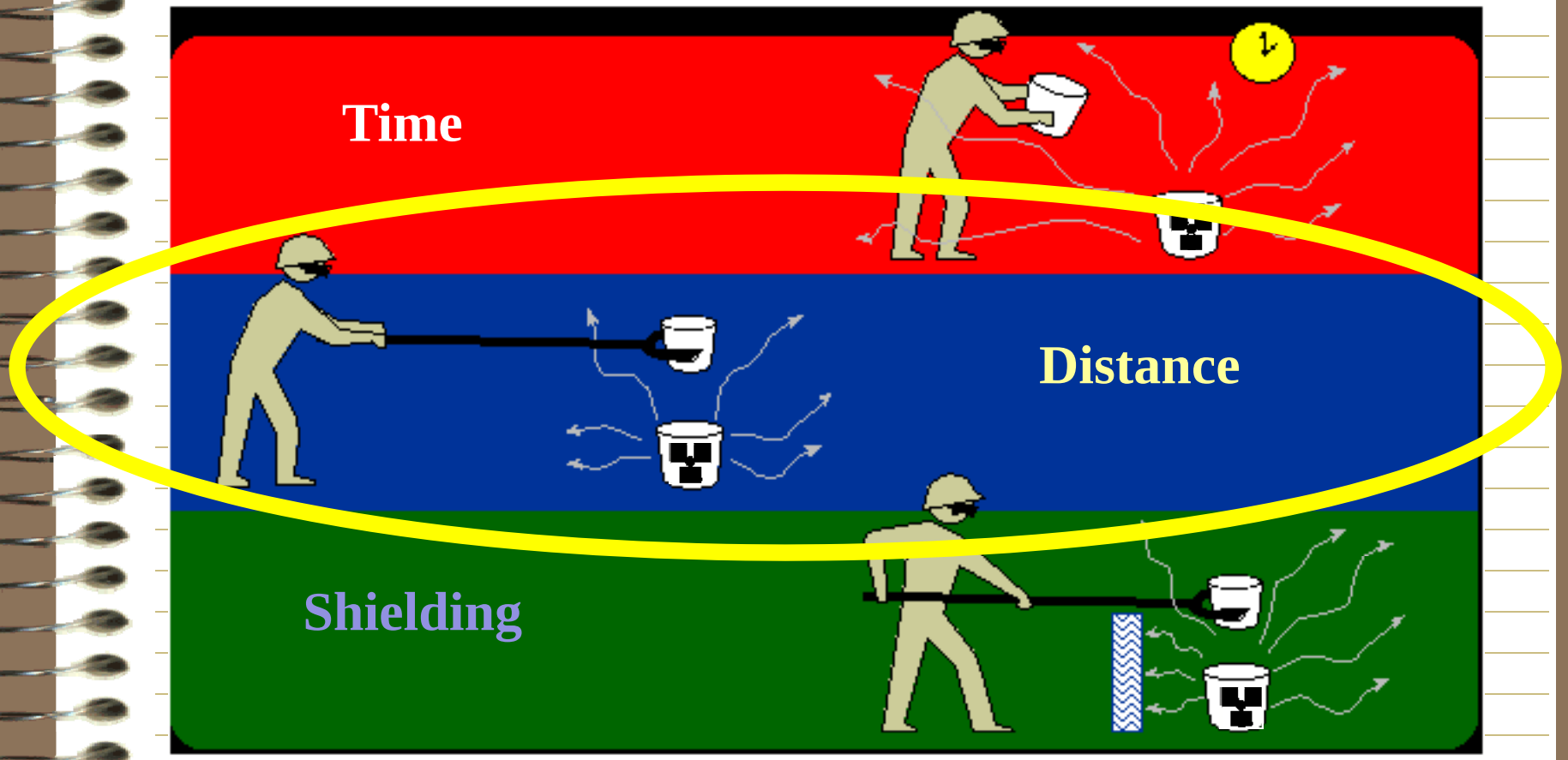
Radiation Detection

- Gas-Filled Detectors
  - Ion Chambers
  - Proportional Counters
  - Geiger-Mueller Tubes
- Scintillation Detectors
- Personnel Radiation Monitoring
  - Film Badges
  - Thermoluminescence Dosimeters
  - Optically Stimulated Luminescence
  - Other Monitoring (i.e. bioassay)

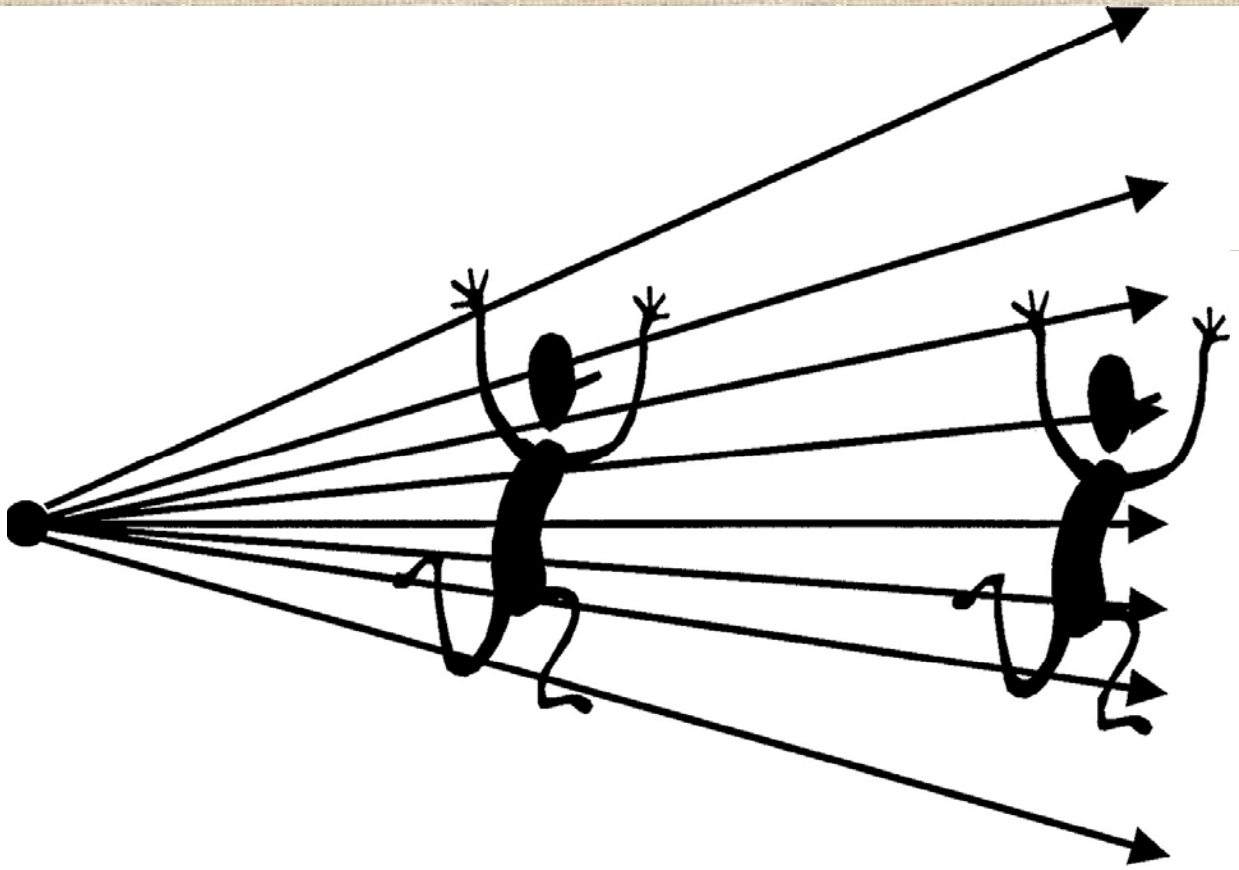
How do we protect ourselves?



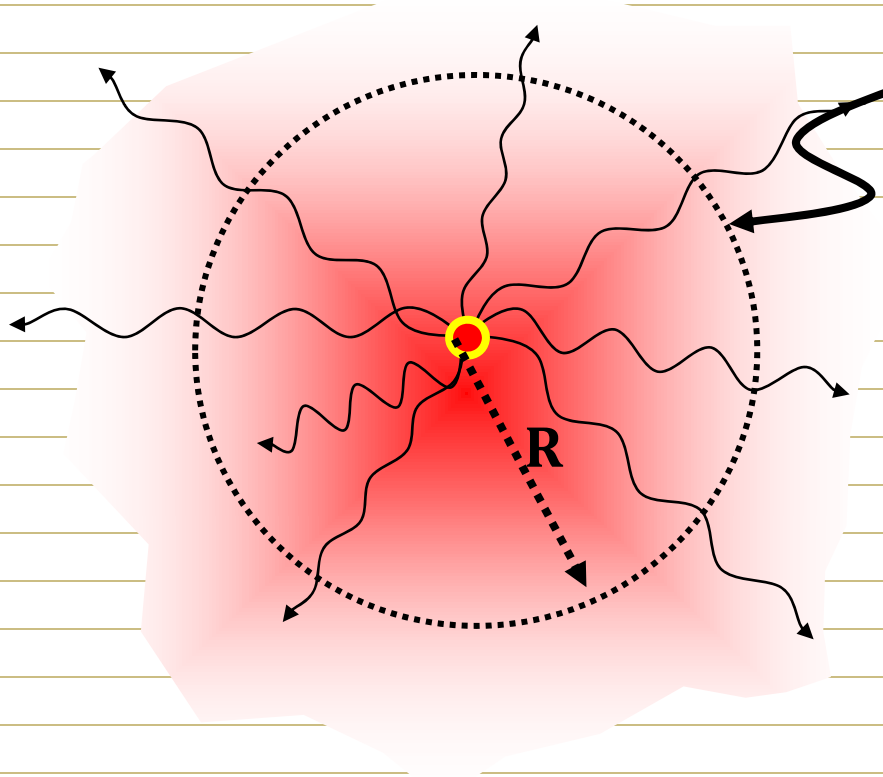
How do we protect ourselves?



Radiation source



Consider the source of radiation as a point at the center of a sphere . . .



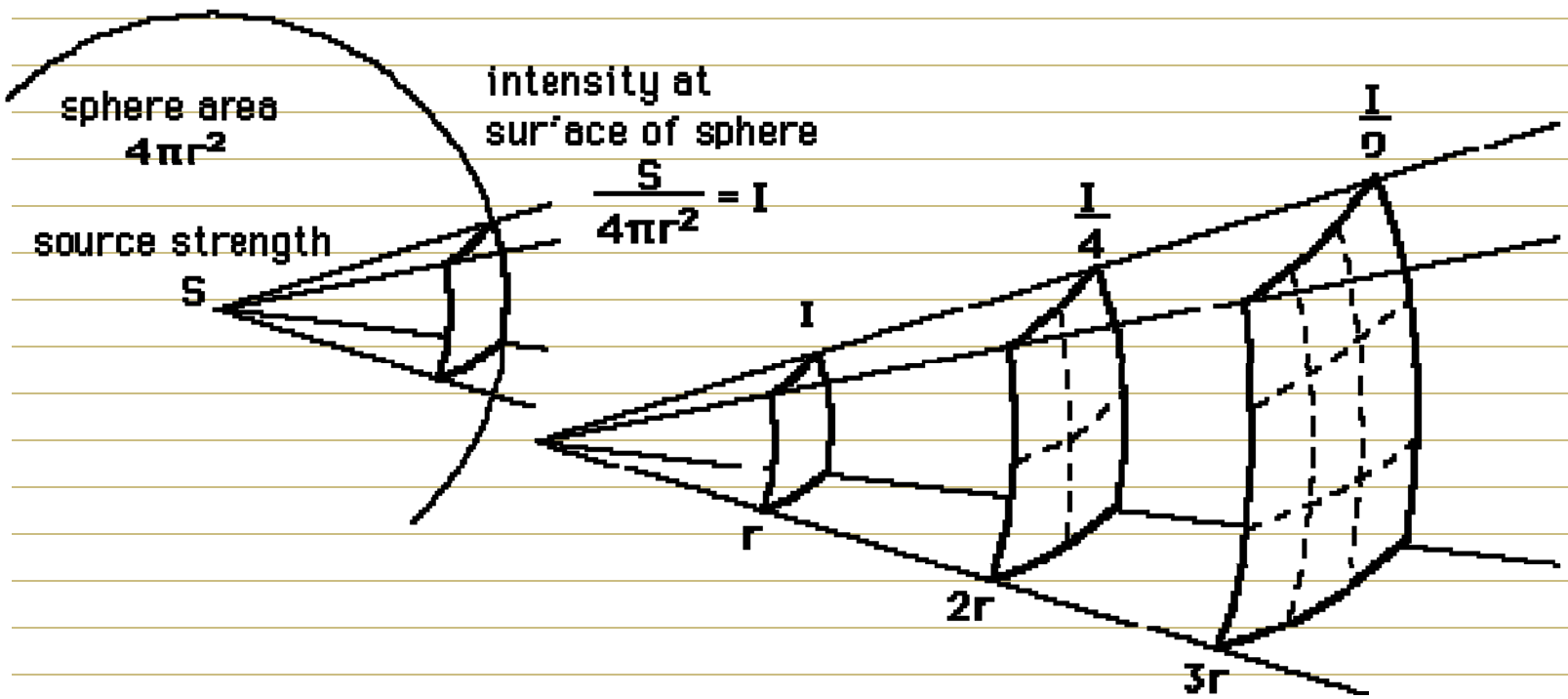
Spherical Surface at distance R

Area (sphere) = $4 \pi R^2$

Radiation Intensity

$\sim 1 / R^2$

Inverse Square Law



Theoretically . . .

$$Itensity \propto \frac{1}{r^2}$$

$$Intensity = \frac{(\text{Constant x Source Strength})}{\text{Distance}^2}$$

$$I_1 \, x \, r_1^2 = \text{Constant } x \text{ Source Strength}$$

$$I_2 \, x \, r_2^2 = \text{Constant } x \text{ Source Strength}$$

Therefore, $I_1 \, x \, r_1^2 = I_2 \, x \, r_2^2$ and

$$I_2 = \frac{I_1 \, x \, r_1^2}{r_2^2}$$

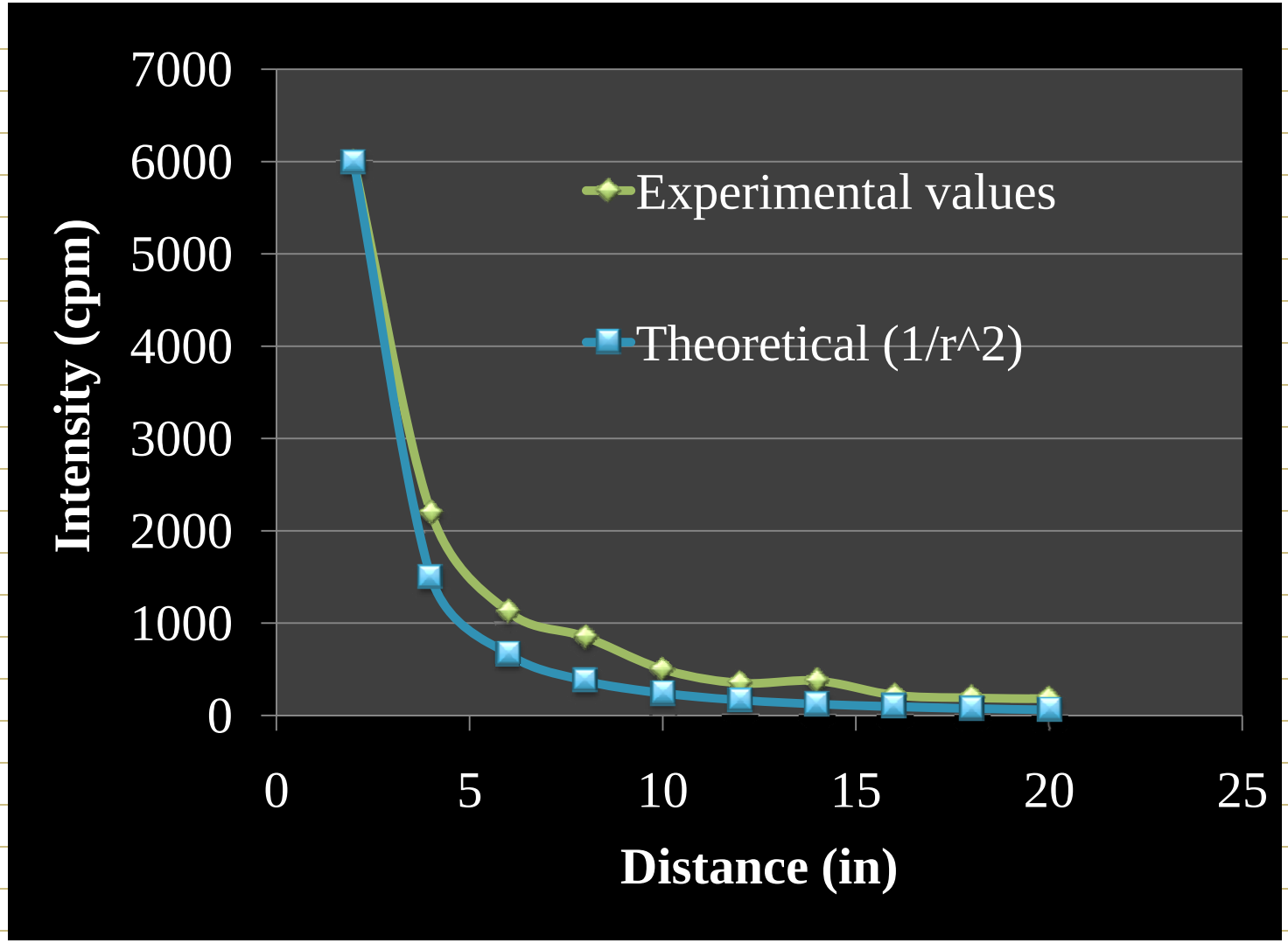
Experiment

Distance from point source (in)	Measured intensity (cpm)
20	180
18	190
16	220
14	375
12	350
10	500
8	850
6	1125
4	2200
2	6000

Experiment + Theoretical

Distance from point source (in)	Measured intensity (cpm)	Theoretical intensity (cpm)
20	180	60
18	190	74
16	220	94
14	375	122
12	350	167
10	500	240
8	850	375
6	1125	667
4	2200	1500
2	6000	6000

Plot and compare



What did the students (freshman) need to know/understand?

- Some basic algebra and geometry
- Meaning of proportionality
- Data collection
- How to apply theory to predict intensities
- How to plot data
- How to interpret and compare data/plot

Concept: Math is a tool used to describe physical systems

Extra slides