Occupational Safety and Health, Radiation Physics and Health, and a Case Study of a DOE Radionuclide Waste Site – Amchitka Island, Alaska

Conrad (Dan) Volz, DrPH, MPH
Bridgeside Point
100 Technology Drive
Suite 564, BRIDG
Pittsburgh, PA 15219-3130
office 412-648-8541 : cell 724-316-5408: Fax 412-624-3040 cdv5@pitt.edu **Assistant Professor, Environmental and Occupational Health, University of Pittsburgh, Graduate School of Public Health** http://www.pitt.edu/~cdv5/ **; Director-Center for Healthy Environments and Communities** http://www.chec.pitt.edu**;**
Director, Environmental Health Risk Assessment Certificate Program http://www.publichealth.pitt.edu/interior.php?pageID=82

Scope of the Occupational Disease and Injury Problem in the United States

Each day, an average of 9,000 U.S. workers sustain disabling injuries on the job, 16 workers die from an injury suffered at work, and 137 workers die from work-related diseases.

The Liberty Mutual 2005 Workplace Safety Index estimates that employers spent $50.8 billion in 2003 on wage payments and medical care for workers hurt on the job.

Worldwide Problem of Silicosis as an Example of Worldwide Burden of Occupational Disease

- During the period 1991 to 1995, China recorded more than 500,000 cases of silicosis, with around 6,000 new cases and more than 24,000 deaths occurring each year mostly among older workers.
- In Viet Nam the cumulative number of diagnosed cases has now reached 9,000. They constitute 90% of all cases of occupationally compensated diseases. Some 18% of workers engaged in surface coal mining, quarrying, foundry and metallurgy have been found to have silicosis.

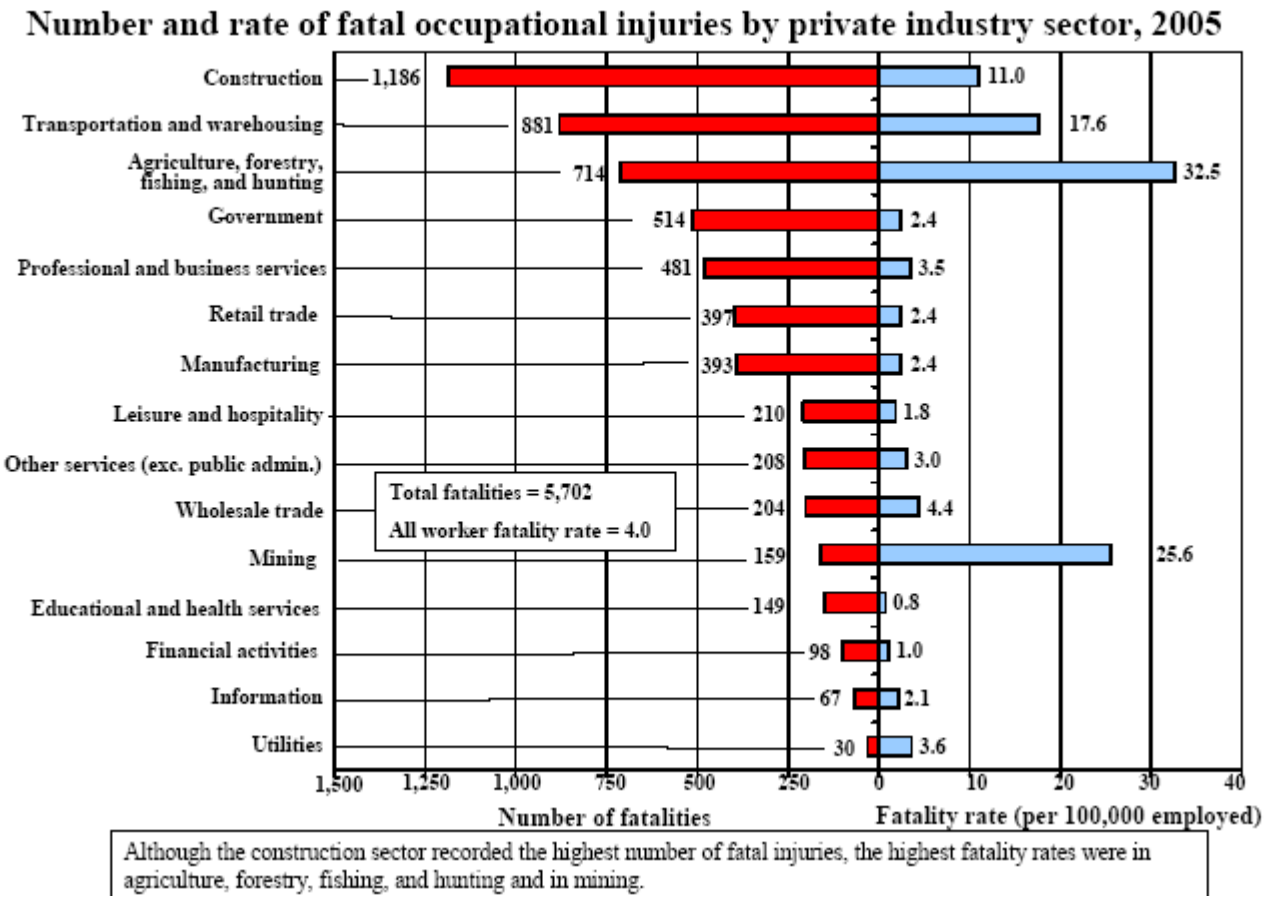
Silicosis in the United States

- In the USA, it is estimated that more than one million workers are occupationally exposed to free crystalline silica dusts (more than 100,000 of these workers are sandblasters), of whom some 59 000 will eventually develop silicosis. It is reported that each year in the USA about 300 people die from it, but the true number is not known.
- Abrasive blasting with silica sand, often used to prepare surfaces for painting, has been associated with exposures 200 times greater than the level recommended by the US National Institute for Occupational Safety and Health. This agency recommended that silica sand be prohibited as an abrasive blasting agent.

Occupational Safety and Health Administration

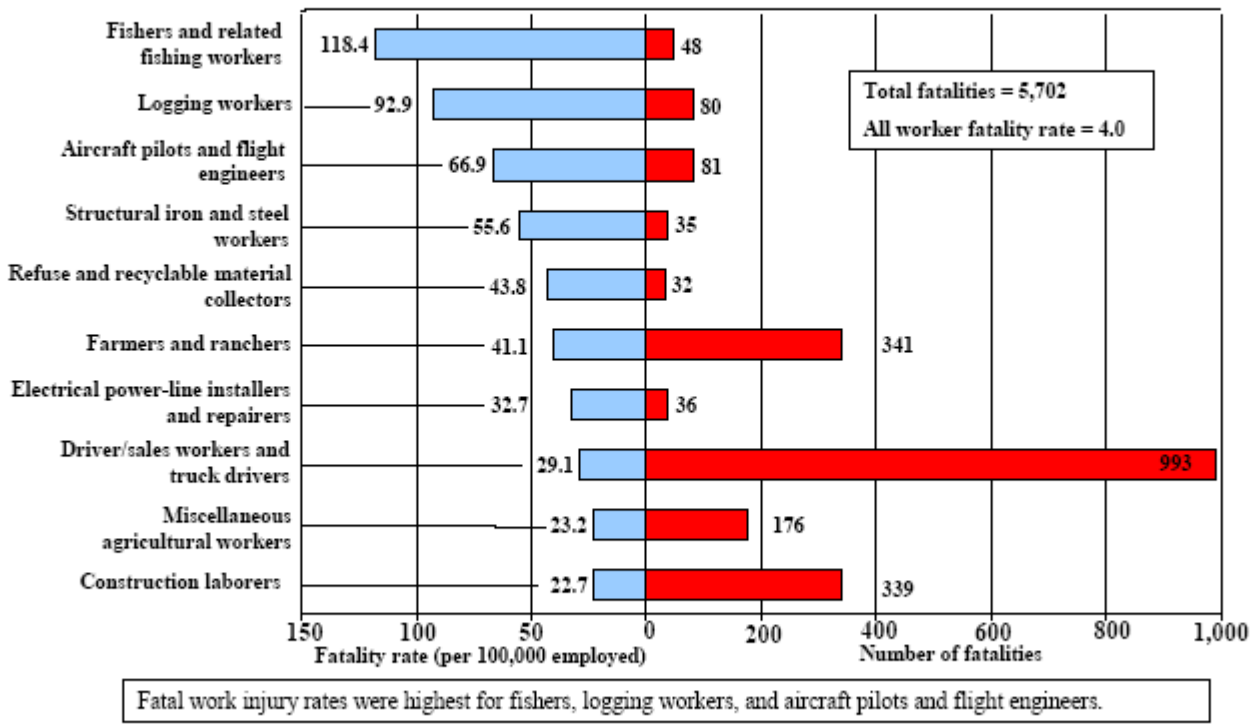
http://www.osha.gov/

- OSHA's mission is to assure the safety and health of America's workers by setting and enforcing standards; providing training, outreach, and education; establishing partnerships; and encouraging continual improvement in workplace safety and health.



http://www.stats.bls.gov/iif/oshwc/cfoi/cfch0004.pdf

Selected occupations with high fatality rates, 2005



Fatal work injury rates were highest for fishers, logging workers, and aircraft pilots and flight engineers.

Rate = (Fatal work injuries/Employment) x 100,000. Employment data based on the 2005 Current Population Survey (CPS) and Department of Defense (DOD) figures.
NOTE: Occupations had to meet predetermined employment and fatality count criteria to be considered for inclusion.
SOURCE: US Department of Labor, Bureau of Labor Statistics, Current Population Survey, Census of Fatal Occupational Injuries, and US Department of Defense, 2005.

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http://www.stats.bls.gov/iif/oshwc/cfoi/cfch0004.pdf

The National Institute for Occupational Health and Safety (NIOSH)

- http://www.cdc.gov/niosh/homepage.html
- The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. NIOSH is part of the Centers for Disease Control and Prevention (CDC) in the Department of Health and Human Services.

Specific Functions of NIOSH

- Develop recommendations for occupational safety and health standards;
  - Perform all functions of the Secretary of Health and Human Services under Sections 20 and 21 of the Act • Conduct Research on Worker Safety and Health (Section 20)
  - Conduct Training and Employee Education (Section 21)
- Develop information on safe levels of exposure to toxic materials and harmful physical agents and substances

Functions of NIOSH continued.

- Conduct research on new safety and health problems;
- Conduct on-site investigations (Health Hazard Evaluations) to determine the toxicity of materials used in workplaces (42 CFR Parts 85 and 85a); and
- Fund research by other agencies or private organizations through grants, contracts, and other arrangements.

Industrial Hygiene History

- As early as fourth century BC, Hippocrates noted lead toxicity in mining industry
- In first century AD, Pliny the Elder devised a face mask from an animal bladder to protect workers from exposure to dust and lead fumes
- In 1700, Bernardo Ramazzini (the "father of industrial medicine") published first comprehensive book that accurately described occupational diseases of most workers of his time
- In 1913, New York Dep't. of Labor and Ohio Dep't. of Health established first state IH programs
- In 1970, U.S. Congress passed Occupational Safety and Health Act

Air Contaminants

- Dusts are solid particles generated by handling, crushing, grinding, colliding, exploding, and heating organic or inorganic materials such as rock, ore, metal, coal, wood, and grain.
- Dusts in the size range of from 1-10 microns in aerodynamic equivalent diameter are respirable.
- Silica, Grain Elevators, Coal etc.

Air Contaminants

- Fumes are formed when material from a volatilized solid condenses in cool air. In most cases, the solid particles resulting from the condensation react with air to form an oxide.
- Examples-Welding fumes, soldering fumes-leads to metal fume fever/zinc chills.

Air Contaminants

- The term mist is applied to liquid suspended in the atmosphere. Mists are generated by liquids condensing from a vapor back to a liquid or by a liquid being dispersed by splashing or atomizing. Aerosols are also a form of a mist characterized by highly respirable, minute liquid particles.
- Pickling and Coating Processes in Steel Production, Oil Mists in Machining.

Air Contaminants

- Fibers are solid particles whose length is several times greater than their diameter, such as asbestos.
- Fibers have a length to width aspect ratio of 3 to 1 or greater and can have aerodynamic equivalent diameters of between 1-10 microns.
- Asbestos Inhalation-asbestosis, lung cancer, mesothelioma.

Air Contaminants

- Gases are formless fluids that expand to occupy the space or enclosure in which they are confined.
- Gases can displace oxygen causing asphyxiation.
- CO-binds preferentially with hemoglobin – carboxyhemoglobin-decreasing the bloods ability to carry oxygen.
- Chlorine gas reacts with water to produce HCL in lung tissue-pulmonary edema.

Air Contaminants

- Vapors are the volatile form of substances that are normally in a solid or liquid state at room temperature and pressure.
- Organic solvents like trichloroethylene and aromatic hydrocarbons like benzene.

Control of Workplace Hazards

- Engineering Controls-First line of defense, removes contaminant before exposure can occur.
- Work Practices-Never dry sweep toxic dusts, always wet clean.
- Administrative Controls-rotation of workers so that they are not always performing the most hazardous work, or doing hazardous work in off hours.
- Personal Protective Equipment-Last line of control, protective clothing, gloves and respirators.

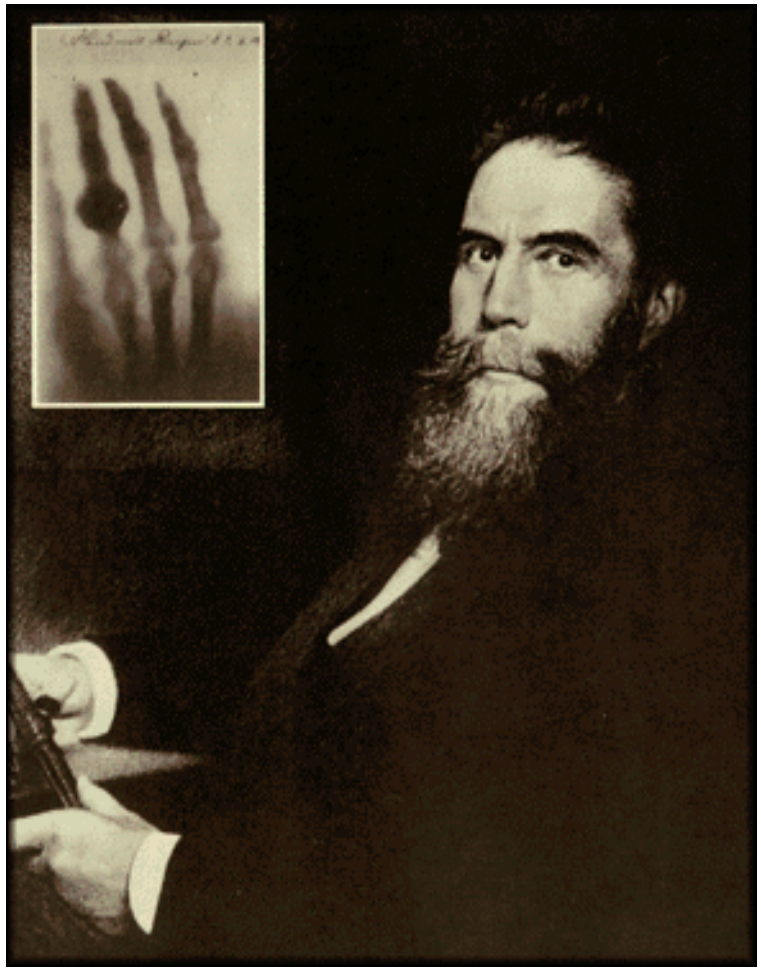
Physical Hazards

- Ionizing and Non-Ionizing Radiation.
- Heat Stress.
- Vibration.
- Noise.
- Illumination.

Ionizing Radiation

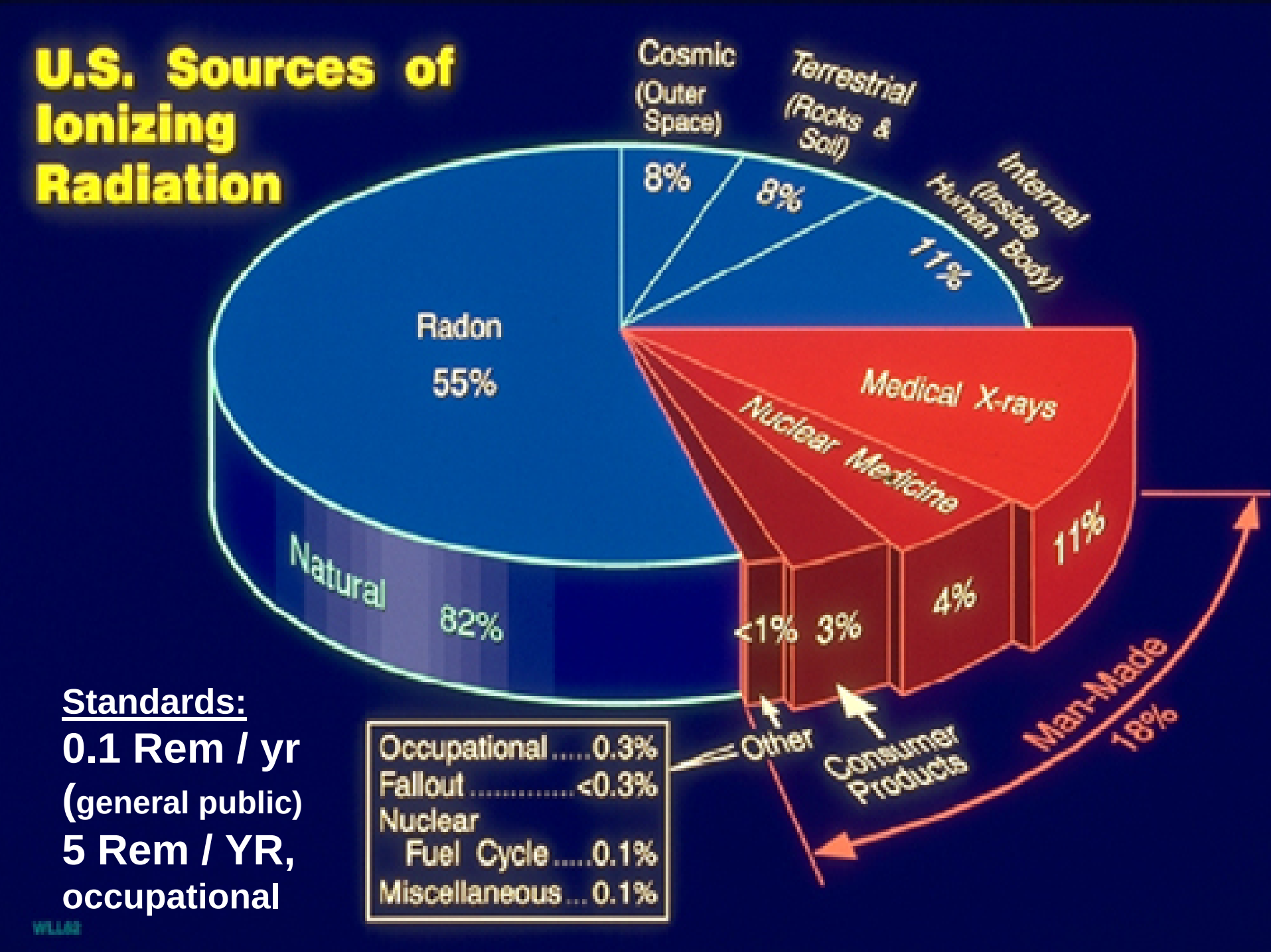
Wilhelm Conrad Roentgen

- November 8, 1895 – Discovers “a new kind of ray”
- He names them X-rays; X representing the unknown.
- December, 1895 – First radiograph of a living object (His wife’s hand).
- January 23, 1896 – First medical use of x-rays reported in the *Lancet*.

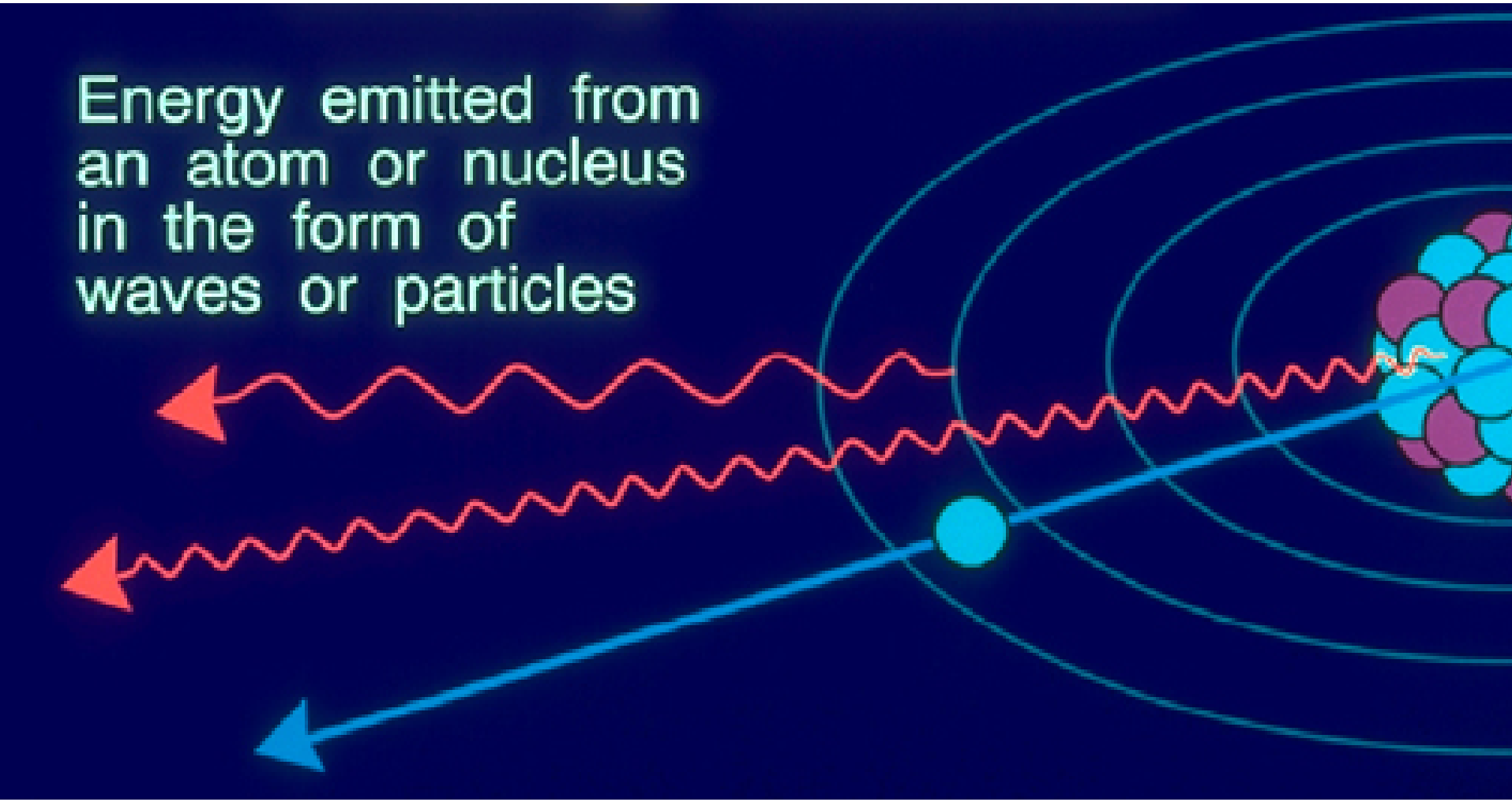


Uses of High-Dose Radiation in U.S.

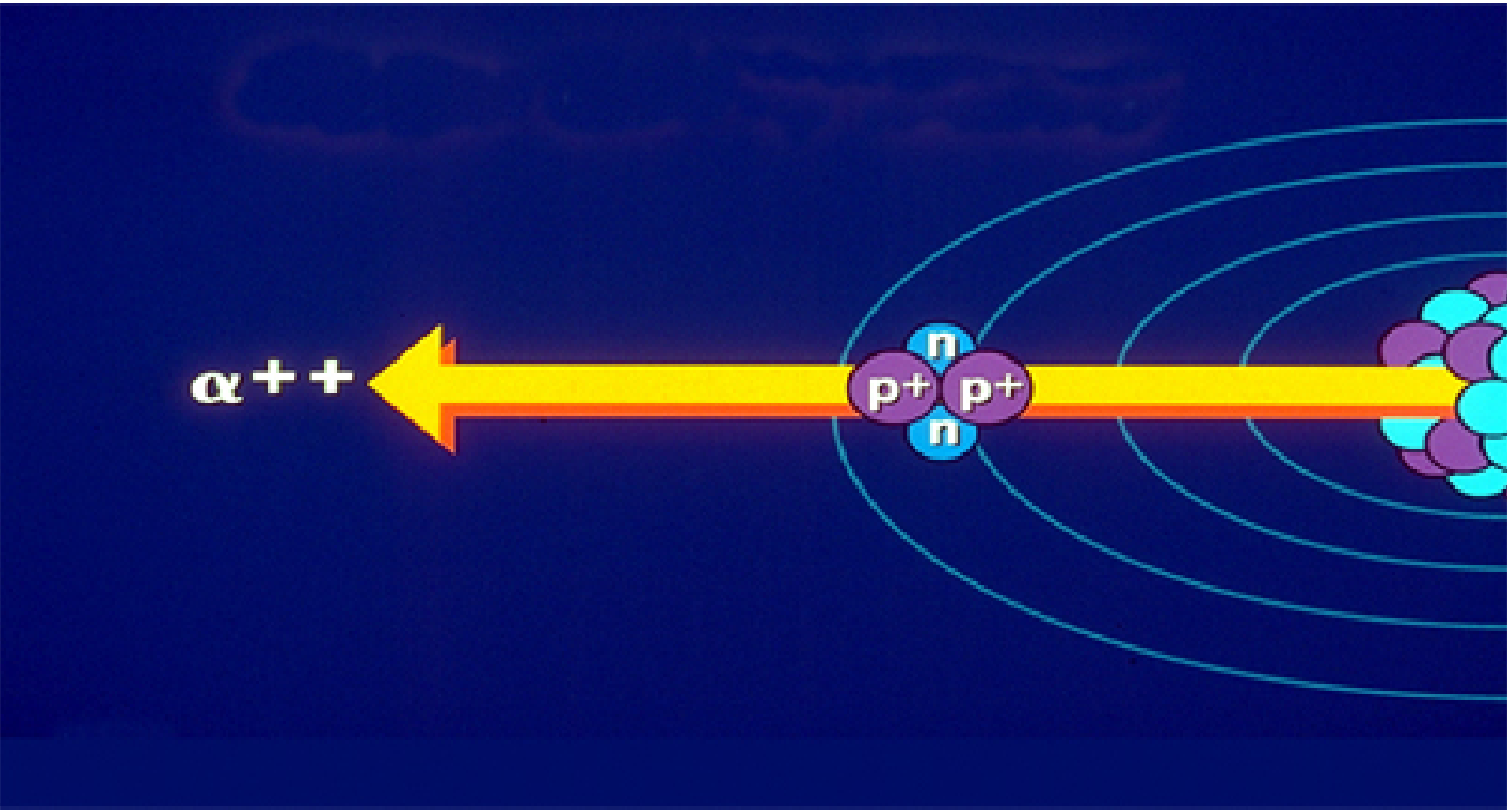
- **Industrial radiography**
- **Power production**
- **Research-Tagging**
- **Processing food and medicines**
- **Medical diagnostic studies**
- **Medical cancer therapy**
- **Atomic Weapons Production**


U.S. Sources of Ionizing Radiation
Cosmic (Outer Space)
8%
Terrestrial (Rocks & Soil)
8%
Internal (Inside Human Body)
11%
Radon
55%
Natural
82%
Medical X-rays
11%
Nuclear Medicine
4%
<1%
3%
Other
Consumer Products
Man-Made
18%
Occupational 0.3%
Fallout .....<0.3%
Nuclear Fuel Cycle 0.1%
Miscellaneous ... 0.1%
Standards:
0.1 Rem / yr (general public)
5 Rem / YR, occupational

1. Ionizing radiation is radiation with enough energy to produce ions in atoms that it strikes.

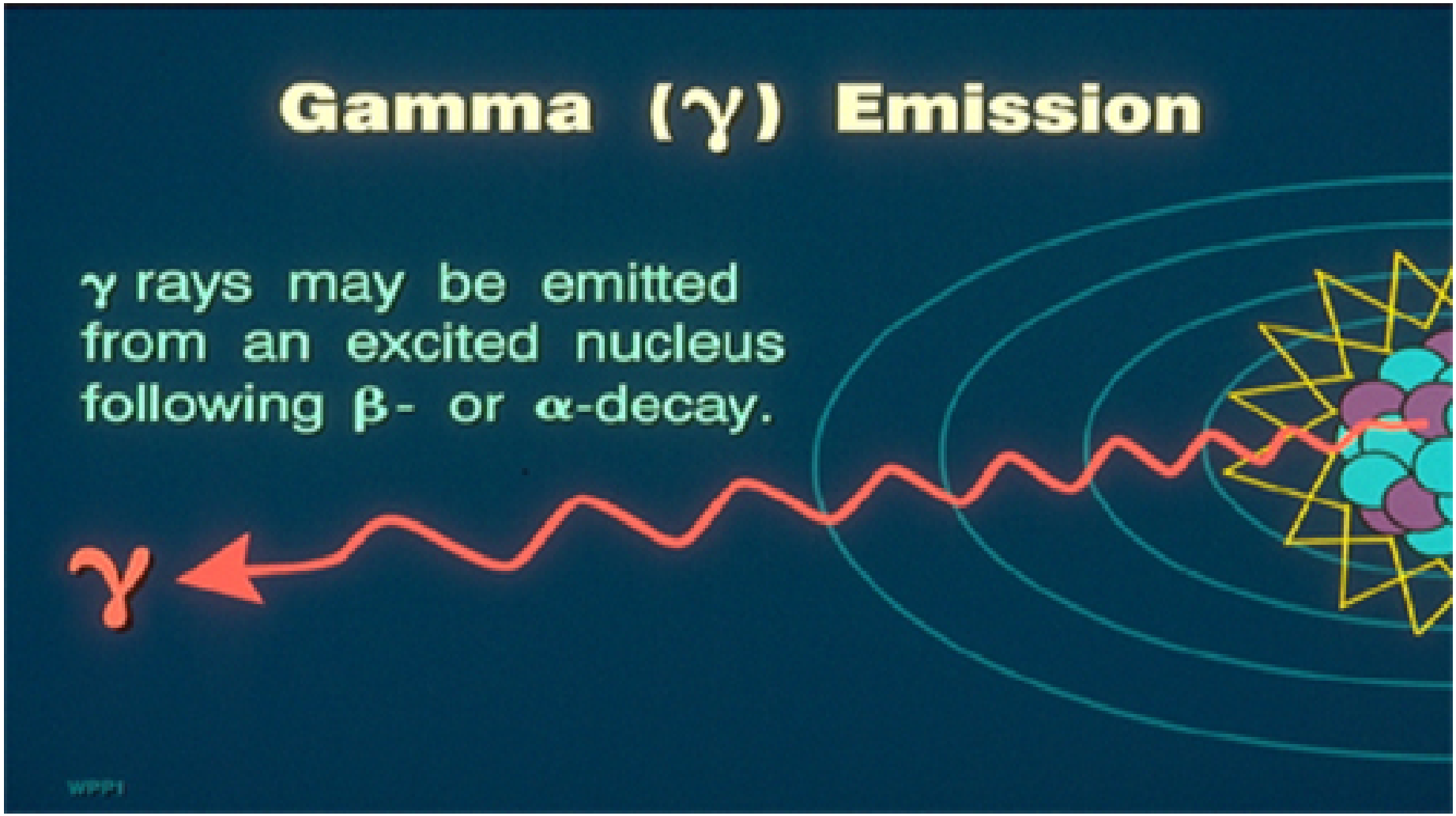


Alpha Particle

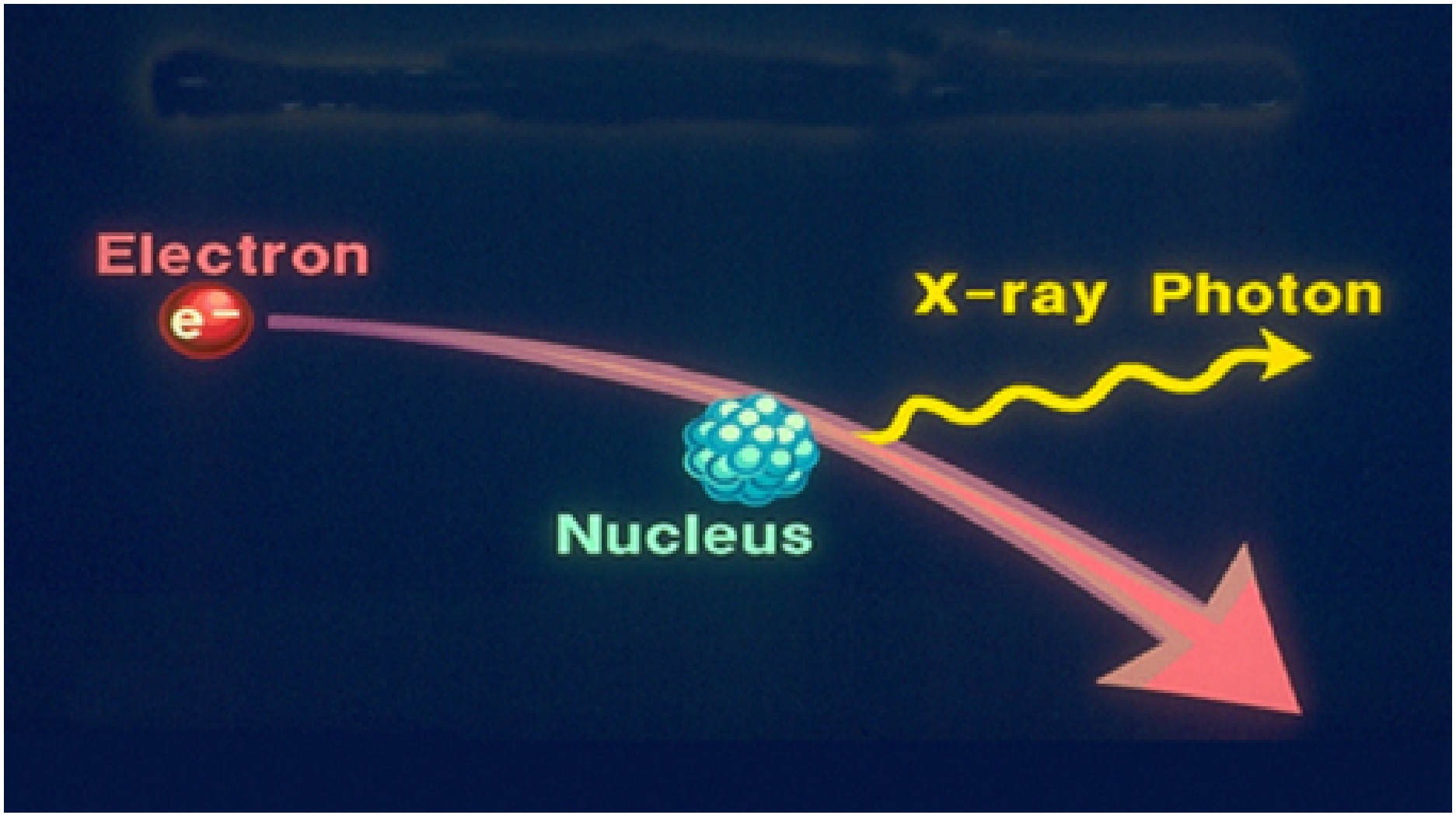


Beta Particle

Gamma Ray

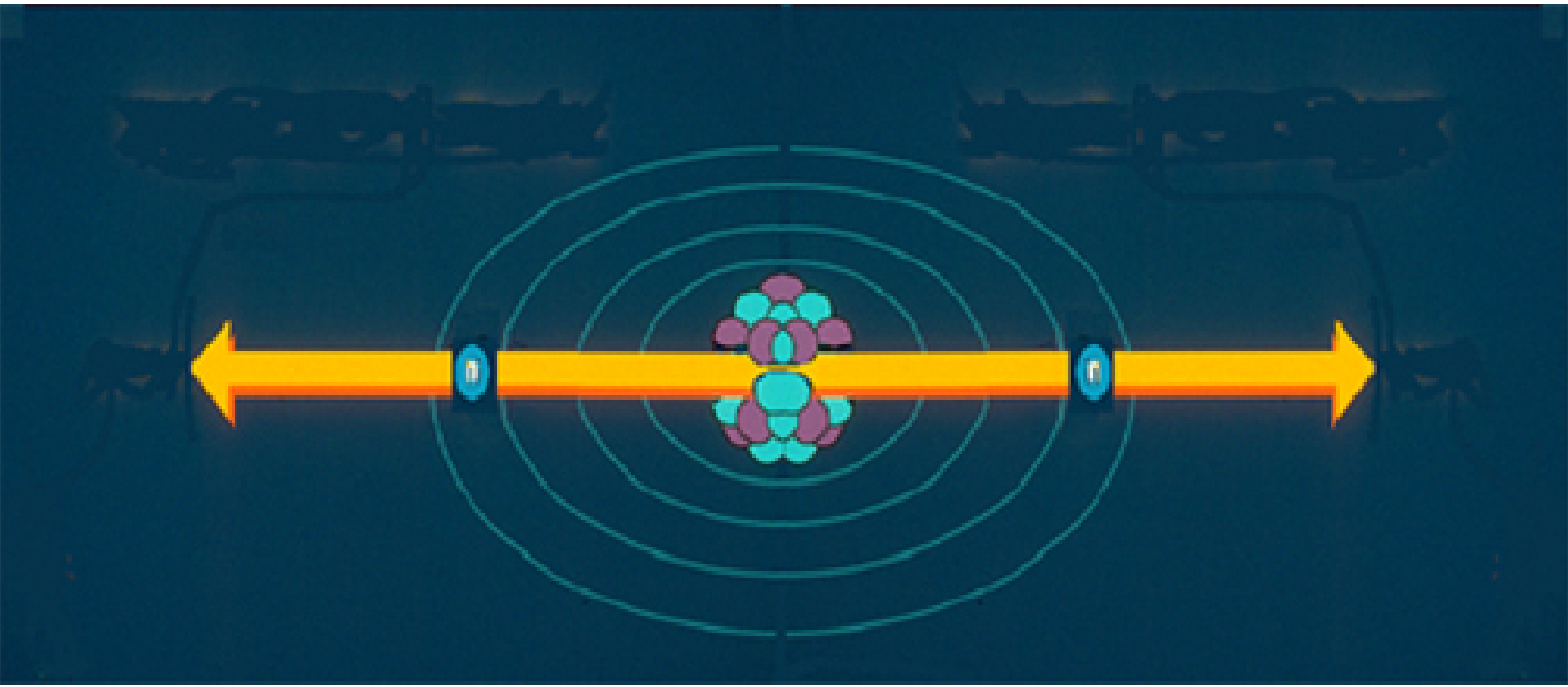

Gamma (γ) Emission
γ rays may be emitted from an excited nucleus following β- or α-decay.
γ

X-Ray



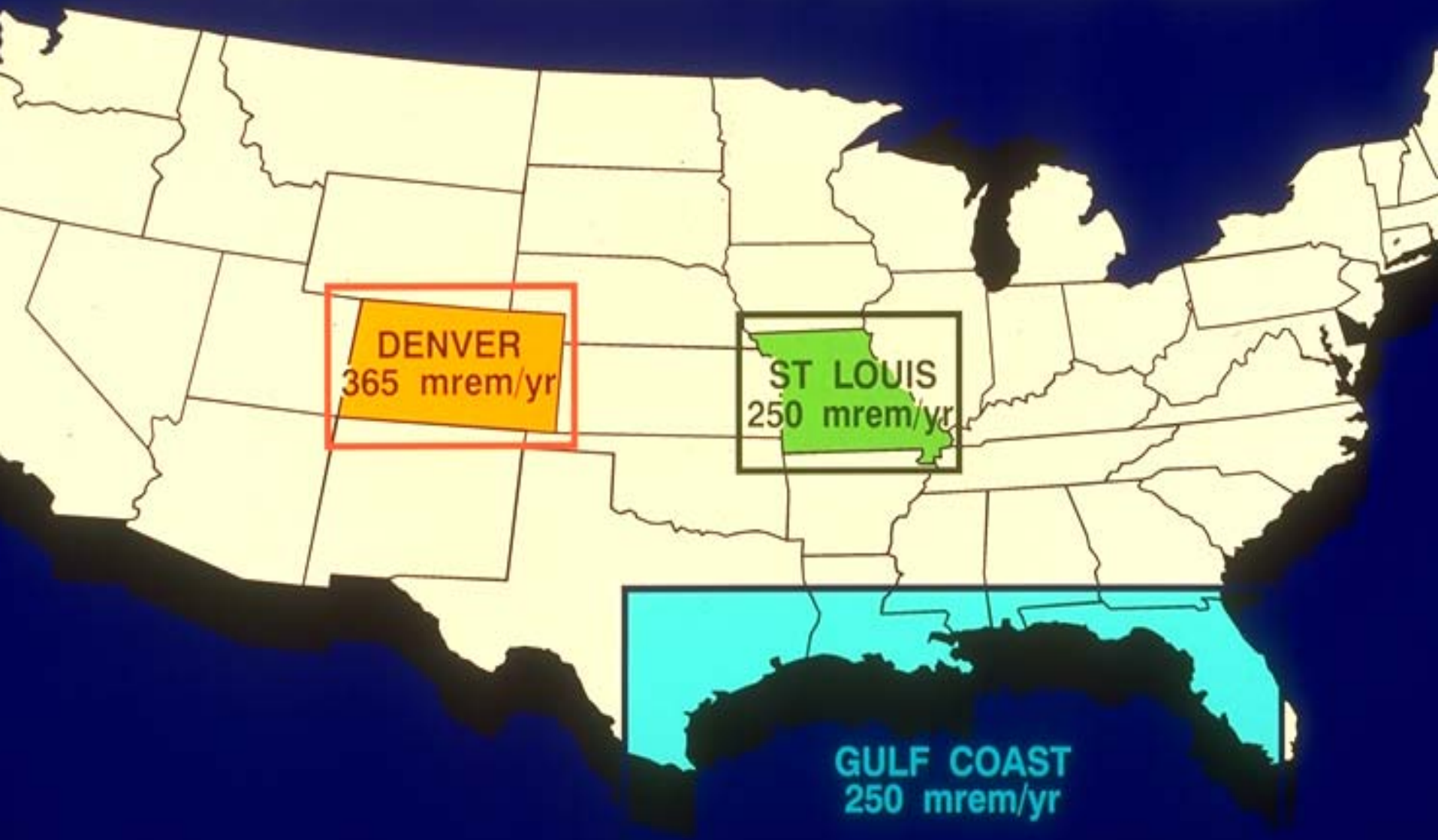
Neutron

Uncharged, heavy



Critical Mass and a Chain Reaction!

Estimated Radiation Dose Rates From Natural Background Radiation in the United States



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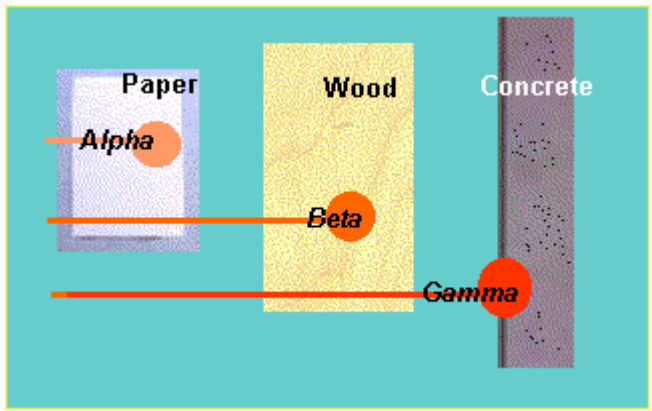
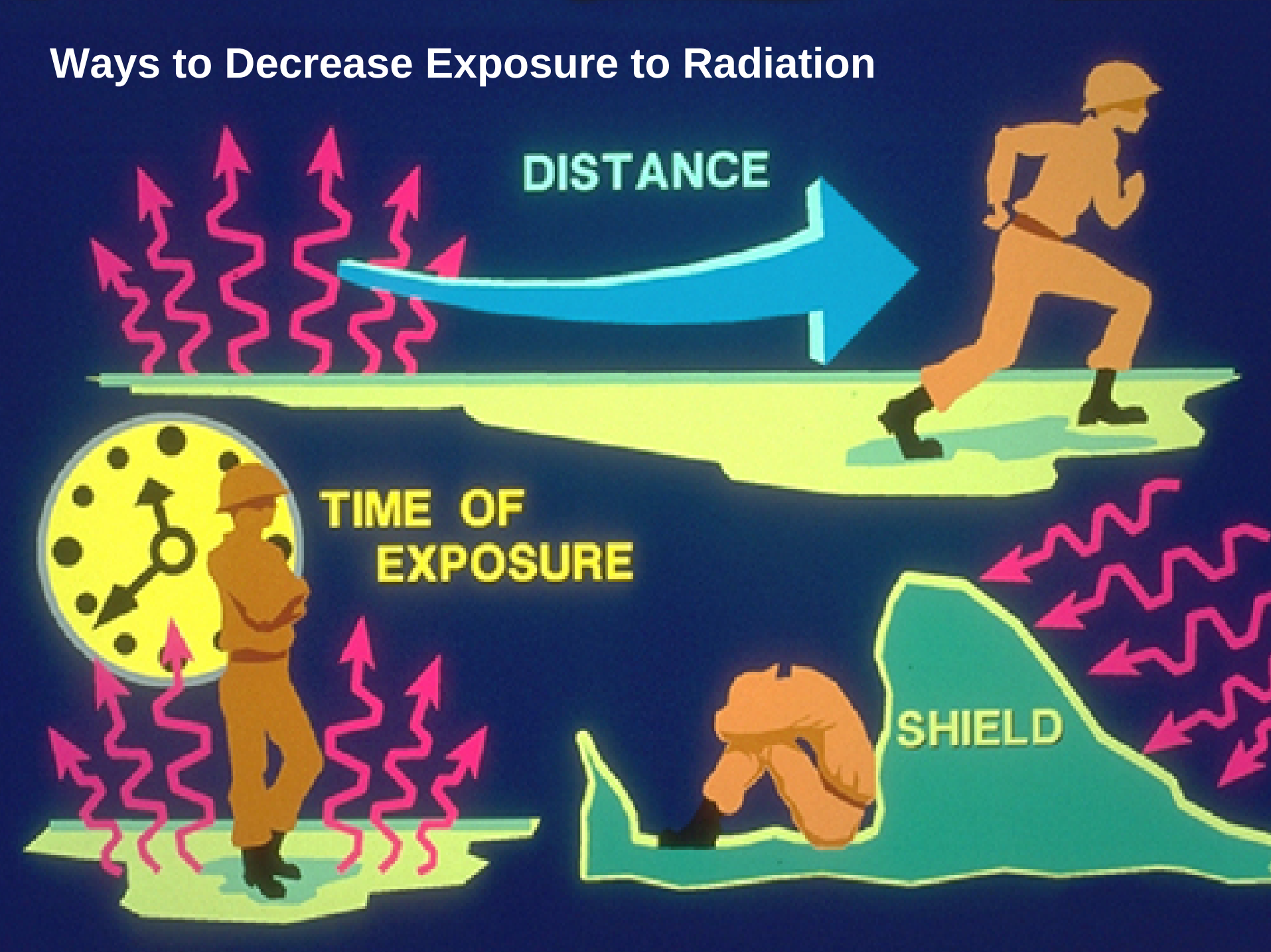
Ionizing Radiation Types- Penetrating Power



Ways to Decrease Exposure to Radiation



Dose

- **Roentgen (R)** - **X, γ-ray exposure, ions in air**
- **Rad (R) -- traditional unit, absorbed dose (Radiation Absorbed Dose)** (= 100 ergs/g)
- **Gray (Gy) -- SI unit of absorbed dose**
  1 Gy = 100 rad = 100 cGy (= 1 J/Kg)
- **Rem (R) -- effective dose (Rad x weighting factors: tissue, radiation type)**
- **Sievert (Sv) -- SI unit effective dose, 100 Rem**

Energy Deposited

Dose is the energy imparted to matter per unit mass of irradiated material

The unit of absorbed dose is the Gray (Gy) or centigray (cGy).

One Gy equals 10,000 ergs deposited per gram of tissue.

1Gy = 100 rads or 1 cGy = 1 rad

Types of Ionizing Radiation in Decreasing Order of Weighting Factor

1. Alpha
2. Neutron
3. Proton
4. Beta
5. Gamma
6. X-ray

Effect of Radiation Weighting per Unit of Absorbed Dose

A tissue absorbing 1 cGy of proton radiation sustains five times (5X) as much biological damage as a tissue absorbing the same quantity of X-rays.

Radiation Effects Depend Upon

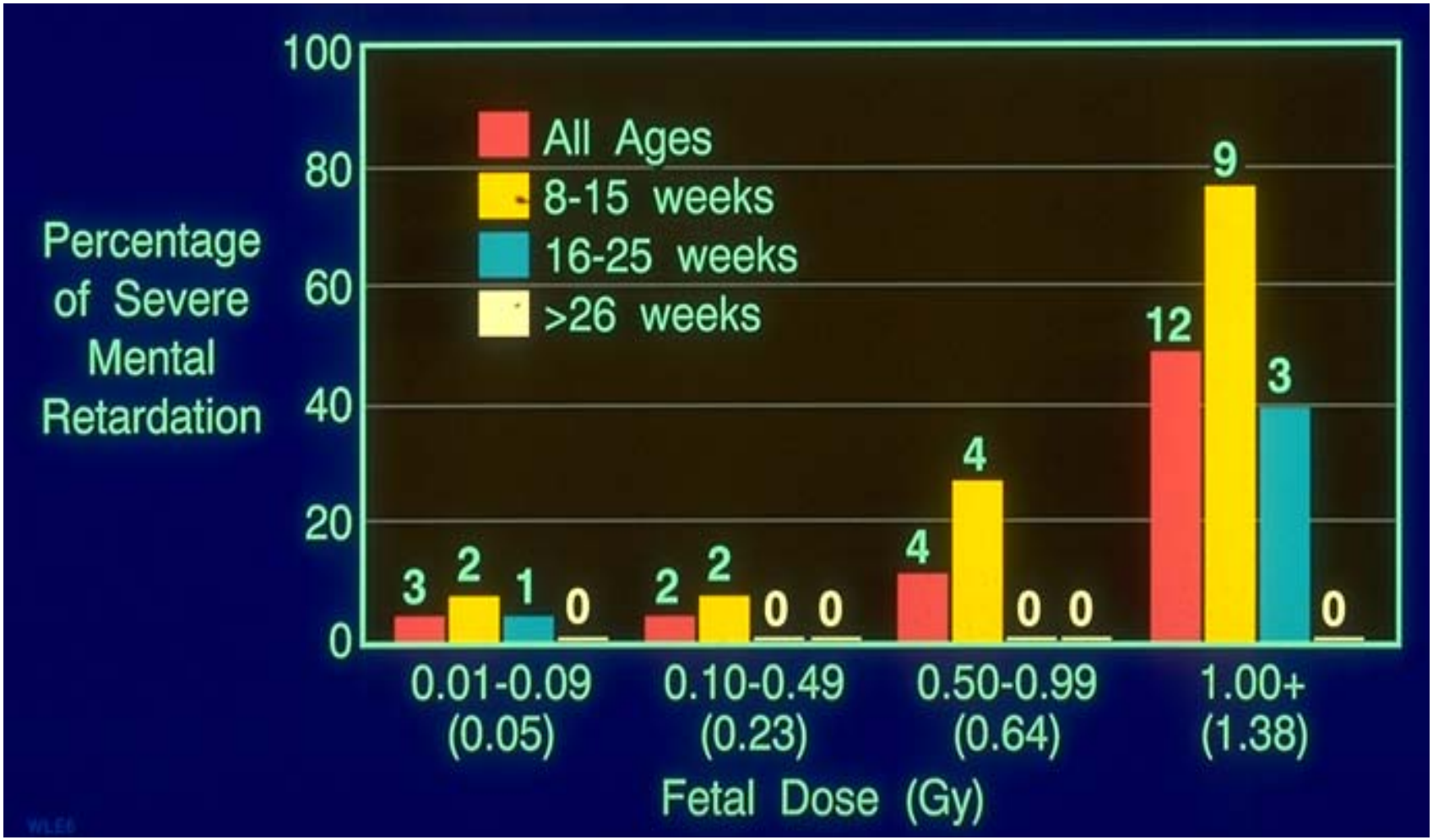
- Energy deposited.
- Radiation type
- Distribution of deposited energy:
  - Whole-body/external
  - Local
  - Internal contamination

Atomic Veterans

- New proposal – August 2001
- Expansion of “radiation-risk activities” to include:
  - Exposure from underground nuclear tests at Amchitka Island, Alaska before Jan. 1, 1974.
  - Service at gaseous diffusion plants in Paducah, KY., Portsmouth, OH., and Oak Ridge, TN (area K25).

- List of illnesses to include
  - Cancer
    - Bone
    - Brain
    - Colon
    - Lung
    - Ovary

Mental Retardation and Fetal Doses
[Combined A-bomb Data (BEIR V)]



Recommended Dose Limits

Application	Dose Limit Occupational	Public
TEDE (whole body)	5 Rem or cSv	100 mrem or .1 cSv
Annual equiv. dose		
- Lens of the eye	15 Rem or cSv	1.5 Rem or cSv
- Skin	50 Rem or cSv	5 rem or cSv
- Hands and feet	50 Rem or cSv	-

CRESP Amchitka Expedition: A Model for Multi- and Interdisciplinary Research into Radionuclide Waste Contamination of the Marine Environment

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Presenter- Conrad (Dan) Volz, DrPH, MPH
Amchitka Project Director
Consortium for Risk Assessment with Stakeholder Participation (CRESP)

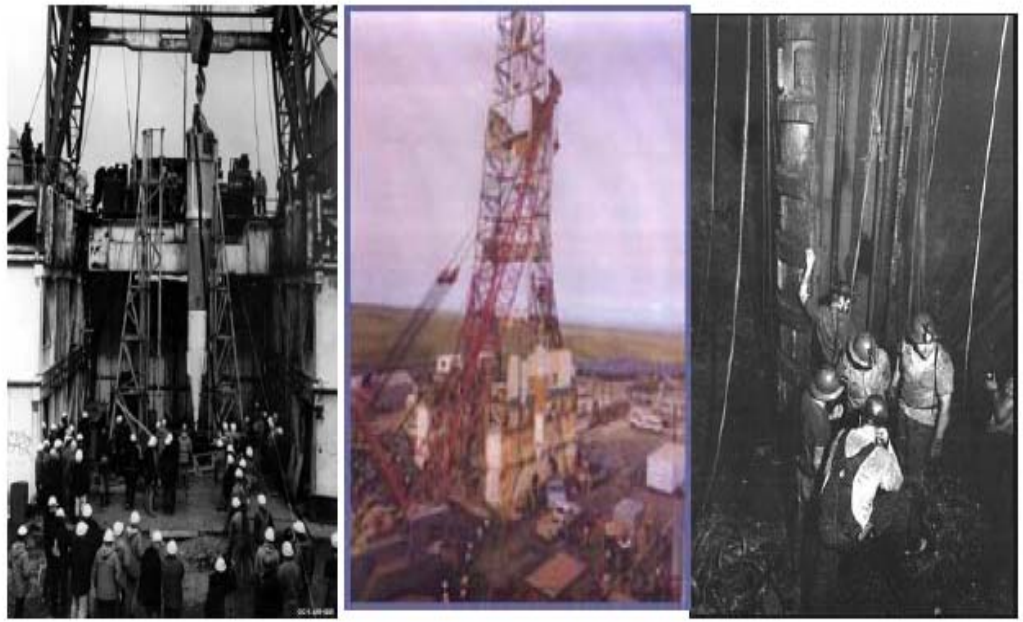
Director
Center for Healthy Environments and Communities
Assistant Professor
University of Pittsburgh Graduate School of Public Health

Underground Nuclear Tests on Amchitka Island

- 1965—Long Shot
  80 Kilotons

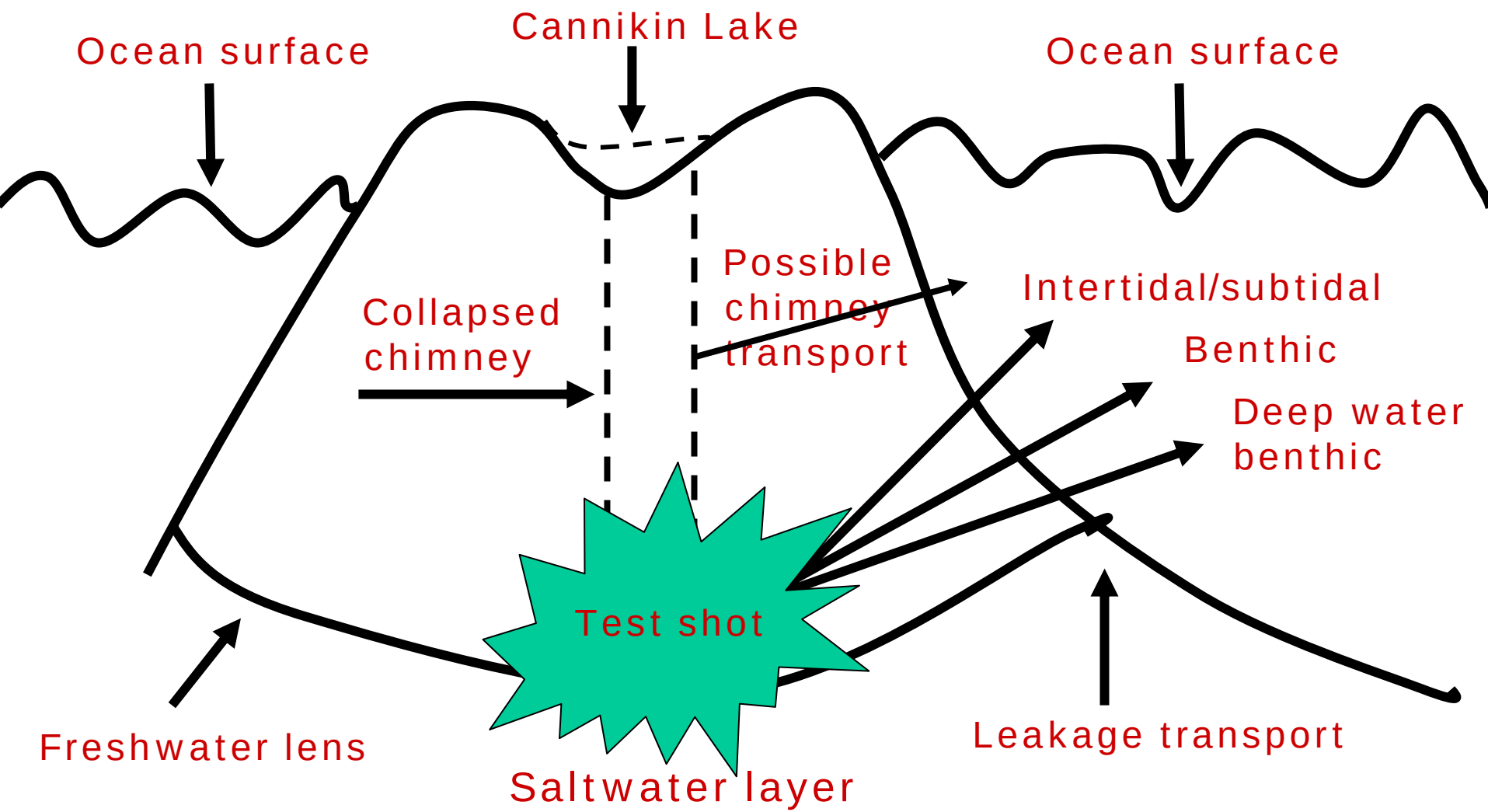
- 1969—Milrow
  1 Megaton

- 1971—Cannikin
  5-8 Megatons
  Largest USA underground test

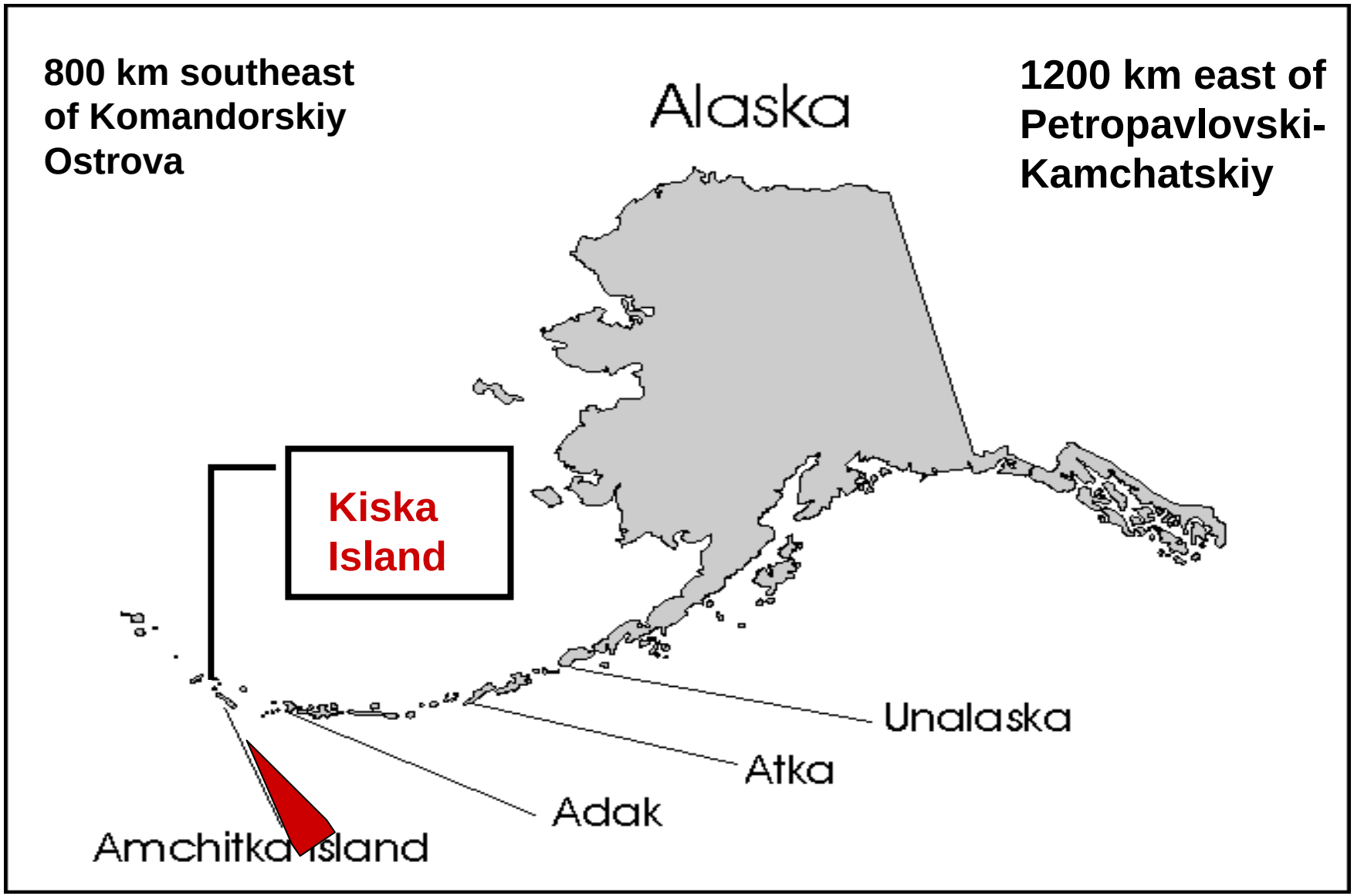


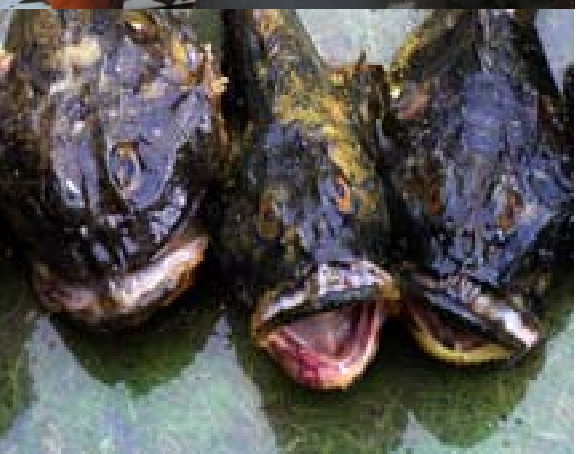
Nuclear Tests on Amchitka Account for 16% of all United States Nuclear Test Explosion Energy.

Amchitka Island Transport of Radionuclides to Marine Areas



Location of Amchitka Island





Reasons for Concern

- Area Supports Robust Biological Productivity—Fishery for USA, Canada, Japan, Korea and Russia

- High Rate of Seismicity

- Movement of Islands

- Plate Tectonics

- Discharge of Radionuclides by Hydrogeological Processes

Expedition Purpose

1. Determine whether there is any current threat to human health and the environment from release into the Island's sea waters from nuclear tests shots at Amchitka.

2. Establish a baseline of biological and physical data that should aid in the development of a long-term stewardship plan.

Physical Expedition June 6 to June 23

- Magnetotelluric Measurements (Land)
- Side Scan Sonar (Sea Bathymetry)
- Multibeam Sonar (Sea Bathymetry)
- Geographic Positioning Systems
- Conductivity/Density/Temperature Probe
- Water and Sediment Sampling
- Ambient and Wipe Sample Radiation Analysis

Multibeam Sonar Drop Long Shot Tows

Biological Collections June 23- July 22

Amchitka (Experimental Sites)

Cannikin Transects

Milrow Transects

Long Shot Transects

Kiska Island (Reference Site)

Intertidal Alaria nana

Contaminants of Concern

Anthropogenic Actinides = Am-241, Pu-238, 239, 240, U-236

Bomb Detonation/Nuclear Power = Cs-137, Eu-152, Co-60, Sr-90, I-129, Tc-99.

Natural Actinides = U-234, 235 and 238

Trophic Levels

Low

Sea Urchins, Limpets, Rock Jingle, Blue Mussel, Ulva, Rock Greenling, Alaria nana and fistulosa

High

Black Rockfish, Tufted Puffin, Eagle, Pacific Cod, Halibut, Octopus, Sea Lion

Final Results

No fissile material or products found in ocean sediments.

Greater subsurface pore volume was present than assumed by earlier studies, suggesting very long travel times for radionuclide migration from the test shots to the marine environment – 1400 to 4700 years for Long Shot.

No radiation survey data above background was found on land or sea.

Expedition personnel radiation dosimetry was **statistically the same as control** dosimeters kept on Adak Island.

Selected Results

No generalized, large scale areas of freshwater discharge were detected.

No underwater fractures or faults were seen in the surveyed areas.

Areas of offshore slumping and compression were seen.

Significant areas of offshore sediment were found, indicating a possible matrix for radionuclide deposition

Selected Results

The **foods consumed by humans are safe** with respect to radionuclides, and levels of radionuclides are well below published human health risk guidance levels.

I-129, Co-60, Eu 152, Sr-90 and Tc-99 in **all biota analysis were below the minimum detection level**.

For Cs-137 high trophic level organisms (Sea Lion, Octopus, Pacific Cod, Halibut, Eagle) **at both experimental and reference sites had higher levels than those lower on the food chain** (all others), ($X2 = 9.53$, $P < 0.02$).

There were **no significant differences for anthropogenic actinide isotopes** (Am-241, Pu-238, 239, 240, U-236) between Kiska and Amchitka, except for Pu 239,240 in Kelp ($X2 = 4.32$, $P = .04$).