

Radiation Safety Training

NOTE: All Training and Testing Material is for LLS Users ONLY!

This training will provide you with a basic overview of radiation safety at Louisiana Light Source. By the end, you should have a good understanding of our radiation policies, general radiation terminology, risks and controls at the facility, and your responsibility with regards to safety at LLS. This training (and annual refresher trainings) are required by Louisiana Department of Environmental Quality (DEQ) regulations and LSU for anyone who may frequent a radiation lab.

Introduction

LLS is a synchrotron radiation research center at Louisiana State University in Baton Rouge. The mission of LLS is to provide infrastructure for research and education in synchrotron-based science and technology. The heart of the facility is a 1.5 GeV electron storage ring that was built exclusively to provide synchrotron radiation. As radiation is being produced, safety measures are necessary for anyone who enters the experimental hall or tunnel.

General Information

So what is radiation? Radiation is energy traveling through space. It can be technically defined as: The emission or transmission of energy in the form of waves through space or through a material medium including electromagnetic, acoustic, and particle radiation, as well as all forms of ionizing radiation.

Why should you care? LLS produces radiation. The closer you get to the inner ring or the linear accelerator tunnel (LINAC) when they are active, the more you are likely to receive a little extra dose. These doses are usually highest during injection or a beam dump.

Is it dangerous? Radiation in high quantities is dangerous. Radiation safety and responsible staff and users at LLS have helped guarantee that no one has ever received a high dose at the facility.

What would you consider more dangerous?



2 days in New York City (threat from air quality)



Riding 1 mile on a motorcycle (threat from collision)



Riding 300 miles in a car (threat from collision)



Eating 40 tablespoons of peanut butter (aflatoxin)



10 charbroiled steaks (aflatoxin)



Smoking 1 cigarette (risk of cancer)



Receiving 3 millirem of radiation (risk of cancer)

According to the Nuclear Regulatory Commission (NRC), these all have the same increased risk of death (1 in 1 million).

Radiation Basics

Radiation is everywhere! Regardless of where you live in the world, you will receive some amount of radiation dose. Background radiation usually refers to radon gas or cosmic radiation.

There are several different units used to describe radiation. While LLS users are not expected to know them all, having a general understanding or recognition of the following terms is helpful. NRC sums these up very nicely:

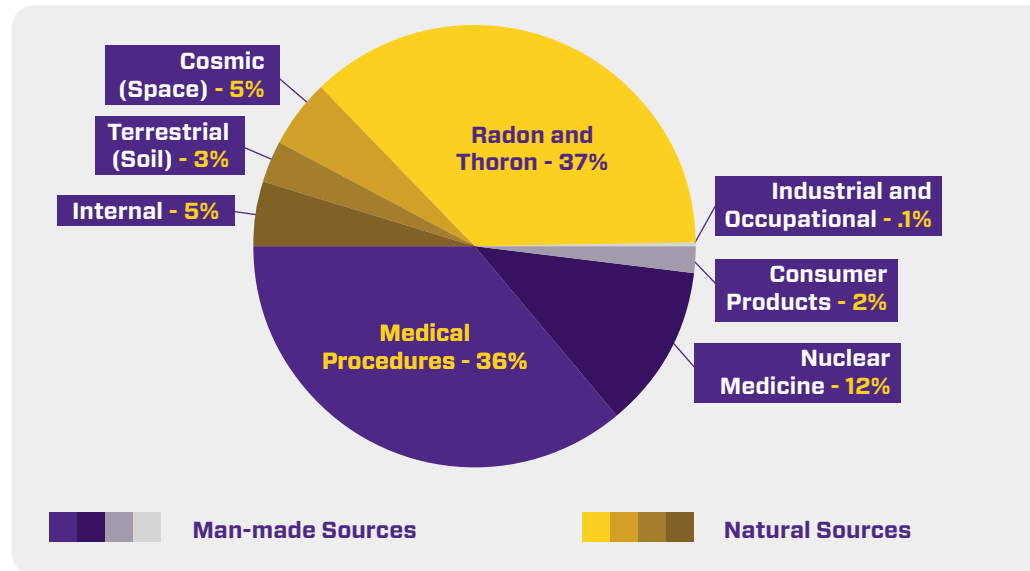
There are four different but interrelated units for measuring radioactivity, exposure, absorbed dose, and dose equivalent. These can be remembered by the mnemonic R-E-A-D, as follows, with both common (British, e.g., Ci) and international (metric, e.g., Bq) units in use:

- Radioactivity refers to the amount of ionizing radiation released by a material. Whether it emits alpha or beta particles, gamma rays, x-rays, or neutrons, a quantity of radioactive material is expressed in terms of its radioactivity (or simply its activity), which represents how many atoms in the material decay in a given time period. The units of measure for radioactivity are the curie (Ci) and becquerel (Bq).
- Exposure describes the amount of radiation traveling through the air. Many radiation monitors measure exposure. The units for exposure are the roentgen (R) and coulomb/kilogram (C/kg).
- Absorbed dose describes the amount of radiation absorbed by an object or person (that is, the amount of energy that radioactive sources deposit in materials through which they pass). The units for absorbed dose are the radiation absorbed dose (rad) and gray (Gy).
- Dose equivalent (or effective dose) combines the amount of radiation absorbed and the medical effects of that type of radiation. For beta and gamma radiation, the dose equivalent is the same as the absorbed dose. By contrast, the dose equivalent is larger than the absorbed dose for alpha and neutron radiation, because these types of radiation are more damaging to the human body. Units for dose equivalent are the roentgen equivalent man (rem) and sievert (Sv), and biological dose equivalents are commonly measured in 1/1000th of a rem (known as a millirem or mrem).

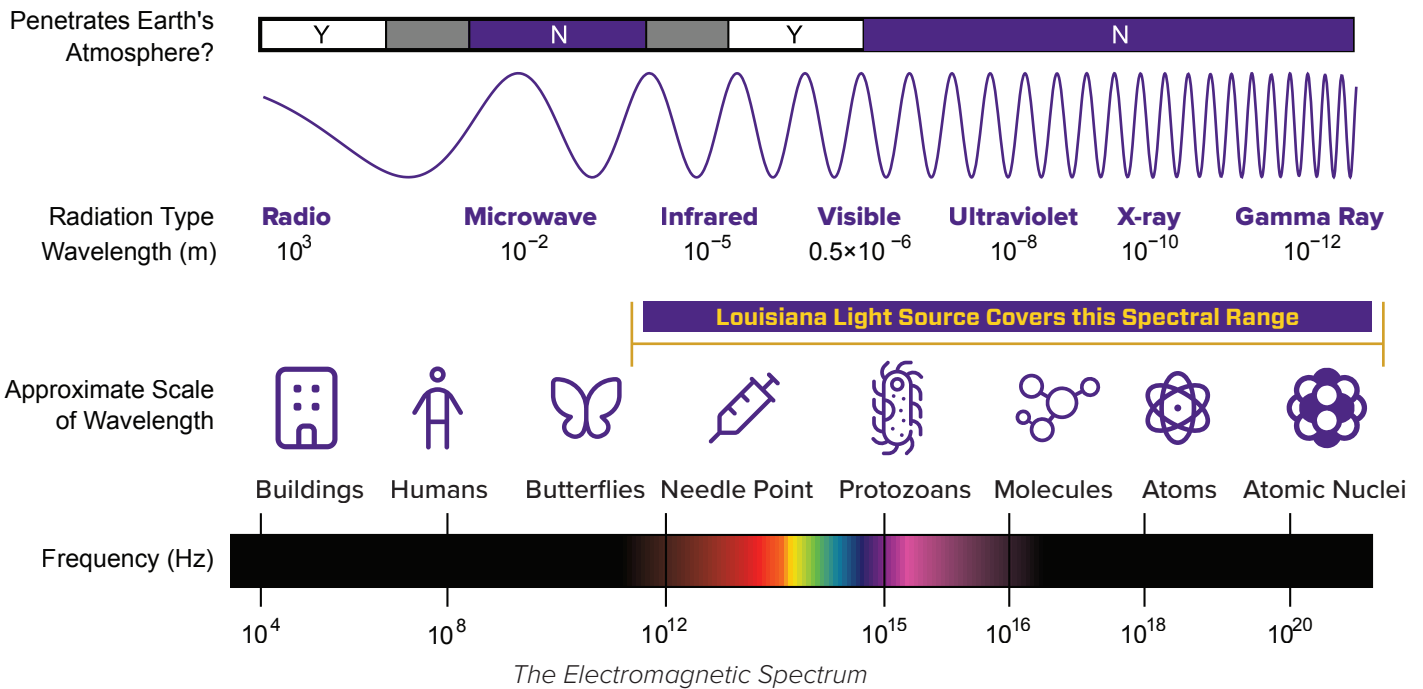
For practical purposes, 1 R (exposure) = 1 rad (absorbed dose) = 1 rem or 1000 mrem (dose equivalent).

Energy Spectrum

Synchrotron light produced by the 1.5 GeV storage ring ranges greatly in the electromagnetic spectrum. LLS produces both non-ionizing and ionizing radiation beams. Ionizing radiation is radiation that can cause an atom to lose or gain electrons, changing its charge. This allows for a variety of research.



Sources of Radiation Exposure in the U.S.



Radiation Biology

Like other toxins and hazards, radiation may cause damage when it interacts with our bodies. Living cells can do one of a few things after exposure to radiation:

- Repair the cell damage.
- Die and be replaced by another healthy cell.
- Incorrectly repair themselves causing additional damage.

The effects of exposure to radiation can be categorized as **Chronic** or **Acute**.

Acute exposures are a large amount of radiation all at once. They do not typically involve less than 10,000 mrem, as no clinical effects are observable at these levels. However, beyond this, health effects may include:

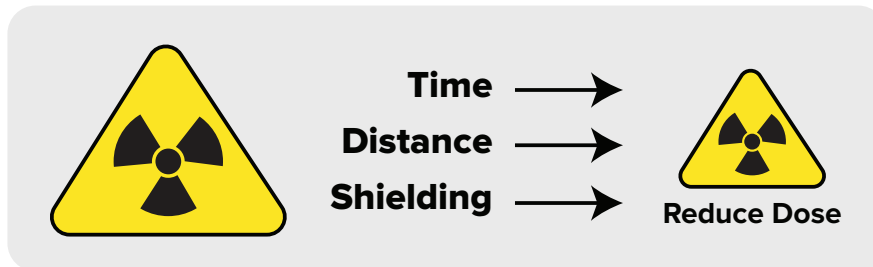
Dose (rem)	Effect
50	Blood count changes
100	Vomiting (threshold)
150	Death (threshold)
320-360	50% mortality with minimal care within 60 days
480-540	50% mortality with medical care within 60 days
800	100% mortality

Other examples of acute effects of radiation include erythema (reddening of skin), cataracts, hair loss, and sterility.

Chronic exposures are smaller doses over a long period of time. Typically, chronic exposures refer to cancer incidence. While risk of cancer due to occupational doses is very small, particularly when compared to background cancer rates, regulations take a very conservative approach, called the Linear No-Threshold Model. Meaning, any amount of radiation may increase your chance of getting cancer. While this is not supported by research, it is a safe approach.

The general approach to radiation safety is keeping in mind ALARA. The goal of radiation safety at LSU is to keep radiation doses As Low As Reasonably Achievable (ALARA). The three keys in achieving this are minimizing time near radiation, maximizing distance whenever possible from radiation sources, and utilizing shielding to attenuate (absorb and block) radiation.

ALARA – As Low As Reasonably Achievable



Regulatory Dose Limits and Radiation Areas

Annual Occupational Dose Limits

Dose	Area
0.5 rem	Child, embryo, or fetus
5 rem	Adult
15 rem	Eye
50 rem	Extremity

The annual dose limit for the general public is 0.1 rem.

Radiation Areas

Level	Rate	Source Distance
Radiation Area	An area where 5 mrem/hr or more is possible	30 cm from the source
High Radiation Area	An area where 100 mrem/hr or more is possible	30 cm from the source
Very High Radiation Area	An area where 500 rad/hr or more is possible	1 meter from the source

Now that you have learned about radiation, let's cover the specifics for Louisiana Light Source.

Access to Louisiana Light Source

The LLS facility typically follows university hours. See the operations schedule for more information.

Unescorted access to the experimental hall requires you to have an active security card and radiation badge. These may be obtained only after radiation safety training and approval by your LLS contact. Security cards will be deactivated if you do not renew radiation safety training annually.

If you are visiting LLS, please have your escort fill out the facility guest log at the entrance to the experimental hall.

A security access card can be obtained after we have received proof of radiation safety training.

Security access cards are coded for:

- experimental hall access
- after-hours access (requires an additional gate key and director approval)

Minors and individuals who are not members of a state-supported institution must sign an indemnification agreement as part of their radiation training. It is the responsibility of the person being trained to inform the facility safety officer if he/she is not a member of a state-supported institution. Please contact the Radiation Safety Officer for more information.

The Experimental Hall

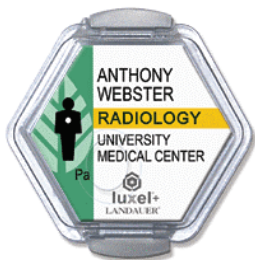
At the center of the hall is the synchrotron ring. This is surrounded by a seven feet high concrete shield. **This area may not be accessed during injection or stored beam.** The radiation interlock system is in place to make sure no one accidentally accesses these areas when there is a potential radiation hazard.

Outside of the concrete walls are the beamlines. Some of these are surrounded by radiation interlocked hatches. **Just like the ring, hatches shall not be accessed when the beamline is in use.**

Two lights are used to indicate energized magnets (yellow), and the arming of the interlock system (red) showing impending or stored beam.

Injection is preceded by a verbal announcement, "Prepare for injection" followed by: "Injection, Injection, Injection." When injection is complete, you will hear "Injection is complete." It is ALARA to maximize your distance from the ring during injection. During injection and a beam dump are when the facility doses will be highest.

The Emergency Procedure and Experimental Hall Policies are posted on our website. Please review them periodically.



Radiation Badges

In general, radiation badges should be worn between the hips and shoulders outside of any clothing with the window facing outward on the portion of the body nearest the radiation source. Each individual that is provided dosimetry is provided with an annual report of their radiation exposure. If you want a copy of your radiation exposure, call the Radiation Safety Office to make your request.

LSU Campus Radiation Safety's Rule

The LSU radiation safety program will be conducted so exposure to faculty, staff, students, the public, and the environment will be maintained as low as reasonably achievable (ALARA) and no radiation

exposure will be received without societal benefit. This will be accomplished without impeding legitimate research or teaching objectives.

Each person who handles radioactive materials or irradiator sources must realize the ultimate success of a radiation safety program lies in responsible actions by individuals in their daily work.

Everyone working at Louisiana Light Source is provided with a radiation badge. The badge is effective in recording all exposures from photons. Badges are to be

kept in your assigned drawer at the facility when you are not wearing them. You must wear your badge whenever you are in the experimental hall. While neutron doses are possible, they are monitored by area badges only.

Wear your badge all the time you are in the experimental hall!

Radiation Monitoring

To best monitor radiation at LLS, several different measurements are taken. These include:

- Ion chambers with live data recording
- Neutron detectors with live data recording
- Environmental badges recording cumulative dose every month
- Environmental badges recording cumulative dose every quarter
- Environmental neutron badges recording cumulative neutron dose every month
- Weekly surveys of injection and stored beam

Training and survey equipment are available for temporary use with the Radiation Safety Officer's approval.

Crash Buttons

Crash buttons are placed in all hutches and in key places around the ring. Pressing them will cause a beam dump. Be observant of their location to avoid accidental triggering and quick access when necessary. These are for emergency purposes only.

Additional Safety Information:

- The stairs to the LINAC and storage ring are very steep, so be cautious!
- Fire extinguishers are located around the perimeter of the experimental hall.
- Emergency plans are posted at each beamline and online.
- There are multiple emergency exits around the experimental hall.
- Fire alarm pull stations are located at the emergency exits.
- The fire alarm system is tied to a security company and will make the necessary notification.
- In an emergency, dial 911.

Personnel Safety Tips:

Do's

- Read and obey signs
- Wear badges while working in the experimental hall
- Leave badges in drawer when off-site
- Ask if unsure
- Verify you have the correct badge
- Request safety data sheets for all chemicals and inform LLS personnel of their use

Don'ts

- Don't climb above the shield
- Don't move shielding
- Don't move monitoring equipment
- Don't lend or borrow badges
- Don't escort visitors without wearing your badge
- Don't work alone
- Don't bring chemicals without LLS approval

Contact the **Radiation Safety Officer** with any questions pertaining to this material.

Key Terminology

Activation – Radiation caused by irradiation (creating a radioisotope by bombarding it with other radiation).

Activity – Number of spontaneous nuclear transformations that occur in a quantity of a radioactive nuclide per unit time.

Beam – Flow of electromagnetic or particulate radiation directed within a small angle.

Dose – Mean energy imparted into mass. More precisely referred to as equivalent, absorbed, or effective dose.

Interlock – A device that automatically shuts off or reduces radiation from an accelerator to prevent unintentional exposure.

Exposure – A measure of radiation in air.

Bremsstrahlung – Radiation associated with the acceleration or deceleration of charged particles.

Synchrotron Radiation – Radiation that occurs when charged particles are accelerated in a curved path or orbit.

For more information:

- [U.S. NRC - Radiation and Its Health Effects](#)
- [University of Wisconsin–Madison - Radiation Training Manual](#)
- [U.S. NRC - Background on Biological Effects of Radiation \(pdf\)](#)
- [U.S. NRC - Biological Effects of Radiation \(pdf\)](#)