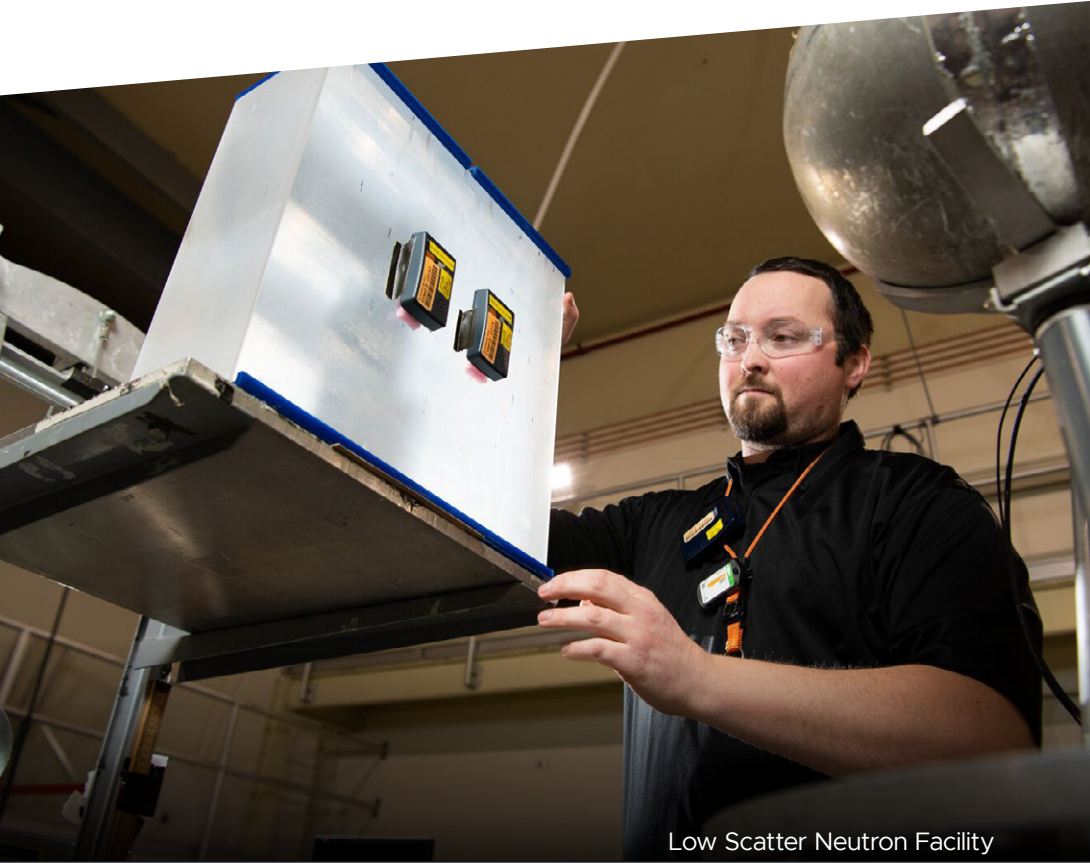


RADIOLOGICAL EXPOSURES & METROLOGY (REM) LABORATORY



Providing highly accurate and precise irradiation and radiation measurements that are impactful on the nation.



Low Scatter Neutron Facility

KEY CAPABILITIES of the REM Laboratory (318 Building)

- | Neutron Metrology
- | Radiation Effects Testing
- | Radiation Measurements and Modeling
- | Dosimetry Development and Testing
- | Radiation Instrumentation Calibration and Testing

IRRADIATION WELLS ROOM

- | Uses include high-throughput calibrations and testing of radiation detectors and other items
- | Four 30 ft deep wells providing direct access to 12 in collimated vertical beams
- | ^{137}Cs gamma from 1×10^{-4} to 10 rad/hr (1×10^{-6} to 0.1 Gy/hr)
- | ^{252}Cf neutron from 3×10^{-3} to 1.0 rem/hr (3×10^{-2} to 10 mSv/hr)



Calibrating radiological equipment



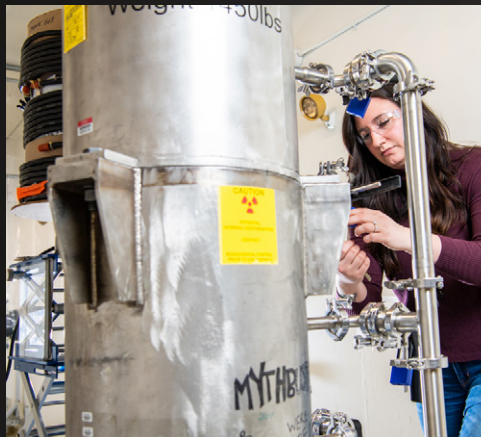
D-T Neutron Generator

LOW SCATTER NEUTRON FACILITY

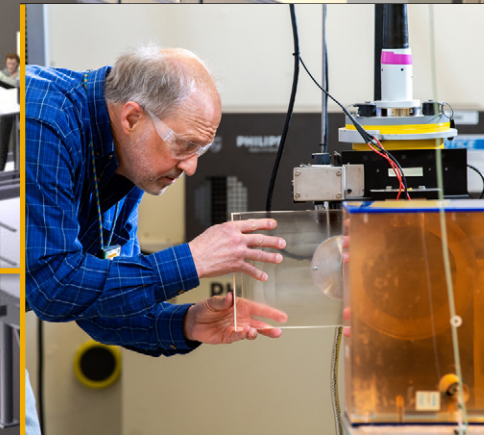
- | Large 30 × 33 × 45 ft reinforced concrete shielded room
- | Uses include neutron dosimeter/detector development and calibrations, and activation analysis
- | D-T neutron generator providing 14 MeV narrow energy spectra with maximum fluence rate of $\sim 2 \times 10^8 \text{ cm}^{-2}\text{s}^{-1}$ at 2 cm distance
- | Unmoderated and moderated ^{252}Cf provide 2 and 0.6 MeV broad energy fission spectra with maximum fluence rate of $\sim 1 \times 10^8 \text{ cm}^{-2}\text{s}^{-1}$ at 2 cm distance. The highest activity ^{252}Cf is approximately 60 GBq (1.6 Ci or 3 mg)
- | Americium-Beryllium (AmBe) sources providing average neutron energy of 4 MeV

HIGH DOSE GAMMA FACILITY

- | Uses include radiation damage testing of materials and electronics, calibrations of dosimeters and survey instruments, and radiation biology research
- | Irradiator utilizes seven high-energy gamma sources (^{137}Cs & ^{60}Co)
- | Up to 1×10^5 rad/hr (1×10^3 Gy/hr) for medium to large items, and up to 5×10^6 rad/hr (5×10^4 Gy/hr) for small items



Long-term high-dose irradiation for cable aging studies



One of over 60 different filter cassettes alters the shape of the photon energy spectrum yielded by a 320 kVp x-ray machine

INDUSTRIAL X-RAY FACILITY

- | Uses include instrument and dosimeter calibrations and irradiations, including irradiation testing of components, and radiation biology research
- | 320 kV potential Industrial x-ray machine in a large 7 m room
- | Over 60 International Organization for Standardization (ISO) and National Institute of Standards and Technology (NIST) beams from 20 keV-320 keV max energy
- | Ultra-low to ultra-high dose rates from 2×10^{-4} to over 6×10^3 R/hr (2×10^{-6} to 60 Gy/hr)

GAMMA BUNKER

- | Thick lead shielding with a center cavity for the source and samples
- | Used for ^{60}Co gamma irradiations for durations of weeks to many months for testing material and component effects from ultra-high doses.
- | Multiple source options allowing 5×10^4 to 7×10^5 rad/hr (5×10^2 to 7×10^3 Gy/hr)
- | Allows for a controlled, elevated temperature environment
- | Cable raceways allow real-time monitoring and control



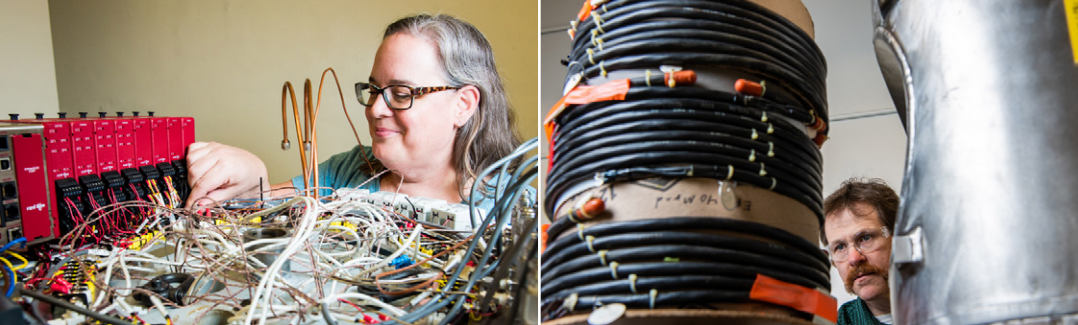
Lead Shielded Gamma Bunker

BETA IRRADIATION FACILITY

- | Uses include dosimeter and survey instrument calibrations, beta source calibrations, and radiation biology research
- | Sources include $^{90}\text{Sr}/\text{Y}$, ^{85}Kr , ^{204}Tl , and depleted uranium slab



Beta Irradiator



PNNL's radiological measurement expertise ranges from helping to prevent nuclear accidents during Hanford site cleanup by determining the rate of flammable gas generation by radiolytic processes (left) to assessing the radiation damage to reactor components for the continued safe operation of existing nuclear power plants (right).

HOW IS PNNL'S REM LABORATORY UNIQUE IN THE COUNTRY?

- | Over 100 highly characterized radiation fields covering a wide range of nuclides and energies
- | Dose rates that range from background level to over 5×10^6 rad/hr (5×10^4 Gy/hr)
- | Experience in all areas of radiation dosimetry (radiation worker protection, medical, industrial/radiation processing, micro-dosimetry, and shielding effectiveness studies)
- | Decades of expertise for support in health physics, radiation dosimetry, research design, Monte Carlo modeling, radiation biology, engineering, and metrology
- | Irradiation of samples within various temperature and humidity environments, and for durations of minutes to many months
- | Digital imaging system, combined with a wide energy range of photon fields, allows unique radiography capability for thin and thick items
- | Most irradiation and calibrations are NIST/National Voluntary Laboratory Accreditation Program accredited (Labcode 105020-0)
- | Irradiation of cameras, sensors, motors, and equipment for deployment in high-radiation environments

DOSIMETRY LAB

- | Houses four different types of passive dosimetry systems that cover the wide dose range involved with radiation worker protection, medical imaging and therapy, and ultra-high dose of materials and electronics
 - | Dual-beam spectrophotometer and fluorescence spectrophotometer – use includes R&D in radiation sensitive phosphors
 - | Male and female anthropomorphic phantoms (RANDO®) for external beam dose studies, including radiation protection garments



Alpha Continuous Air Monitors for Qualification Testing

Anthropomorphic phantoms with internal cavities for thermoluminescent dosimeters (TLDs)



PROJECT SUPPORT

- | Radiological health physics and radiation dosimetry expertise
- | Irradiation design and engineering expertise
- | Monte Carlo modeling & 3-D printing
- | Measurement and test equipment calibrations conforming to ISO/IEC 17025 and ASME NQA-1-2008/1a-2009
- | Radiation Non-Destructive Assay (gamma spectroscopy & neutron detection)

ENVIRONMENTAL TESTING LAB

- | Used for temperature and humidity testing of small to very large items, and vibration testing for small to medium size test items
- | Large walk-in environmental chamber (5×5×7 ft) capable of -40°C to +50°C
- | Medium environmental chamber (2×2.3×2.3 ft) capable of -60°C to +200°C
- | Small environmental chamber (1.6×1.6×1.6 ft) capable of -60°C to +100°C
- | Temperature Shock and Temperature Ramp testing
- | Humidity testing from approximately 20% to 95% RH
- | Concurrent combinations of temperature, humidity, and radiation possible



Walk-in Environmental Chamber

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PNNL staff support nuclear worker protection by testing and calibrating personal contamination monitors.



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