

# RADIOLOGICAL EXPOSURES & METROLOGY (REM) LABORATORY



Providing highly accurate and precise irradiations and radiation measurements that are Impactful to the Nation.



Low Scatter Neutron Facility

## KEY CAPABILITIES of the REM Laboratory (318 Building)

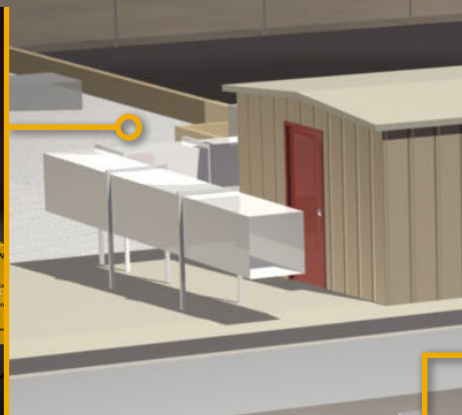
- | Neutron Metrology
- | Radiation Effects Testing
- | Radiation Measurements and Modeling
- | Dosimetry Development and Testing
- | Radiation Instrumentation Calibration and Testing

### 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
- $^{137}\text{Cs}$  gamma from  $1 \times 10^{-4}$  to 10 rad/hr ( $1 \times 10^{-6}$  to 0.1 Gy/hr)
- $^{252}\text{Cf}$  neutron from  $3 \times 10^{-3}$  to 1.0 rem/hr ( $3 \times 10^{-2}$  to 10 mSv/hr)



Criticality Safety Alarm being tested with a neutron irradiation well



Setup for Moderated  $^{252}\text{Cf}$  Irradiation (left), D-T Neutron Generator (right)

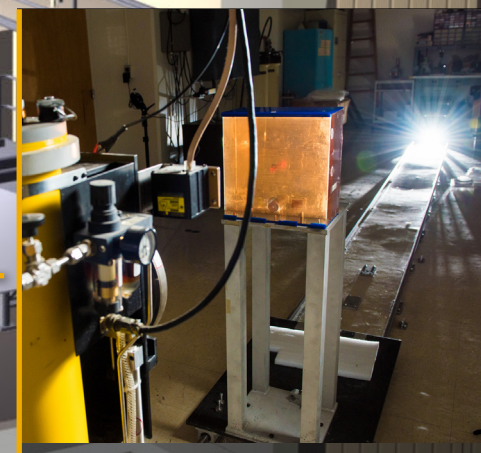
### LOW SCATTER NEUTRON FACILITY

- Uses include neutron dosimeter/detector development and calibrations, and activation analysis.
- D-T neutron generator providing 14 MeV narrow energy spectra at  $\sim 10^9$  n/cm<sup>2</sup> s flux
- Unmoderated and moderated  $^{252}\text{Cf}$  provide 2 and 0.6 MeV broad energy spectra of  $\sim 4 \times 10^7$  n/cm<sup>2</sup> s flux. AmBe sources providing average energy of 4 MeV are also available.
- Large 33x30x10 ft reinforced concrete shielded room
- Dose rates from  $5 \times 10^{-7}$  to over 10 rem/hr ( $5 \times 10^{-9}$  to over 0.1 Sv/hr)

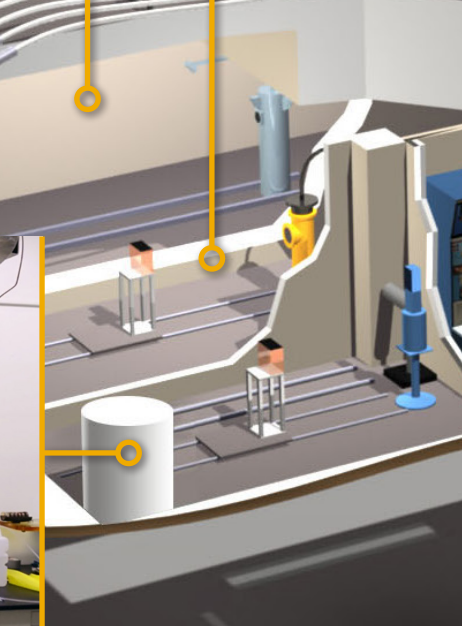


### INDUSTRIAL X-RAY FACILITY

- Uses include instrument and dosimeter calibrations and irradiations, including radiation testing of components, and radiation biology research
- 320 kV potential Industrial X-ray machine in large 7 m room
- Over 60 ISO and NIST beams from 20 keV-320 keV max energy
- Ultra-low to ultra-high dose rates from  $2 \times 10^{-4}$  to over  $6 \times 10^3$  R/hr ( $2 \times 10^{-6}$  to 60 Gy/hr)



Dosimeter irradiations on phantom



### GAMMA BUNKER

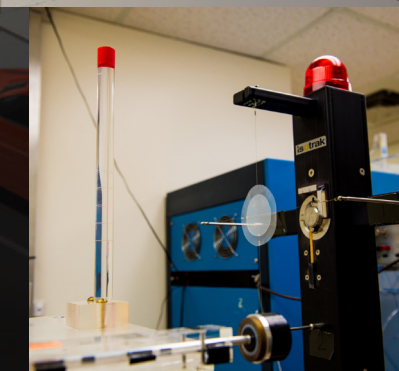
- Thick lead shielding with center cavity for source and samples
- Used for  $^{60}\text{Co}$  gamma irradiations for durations of weeks to many months for testing material and component effects from ultra-high doses.
- Multiple source options allowing  $5 \times 10^4$  to  $7 \times 10^5$  rad/hr (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



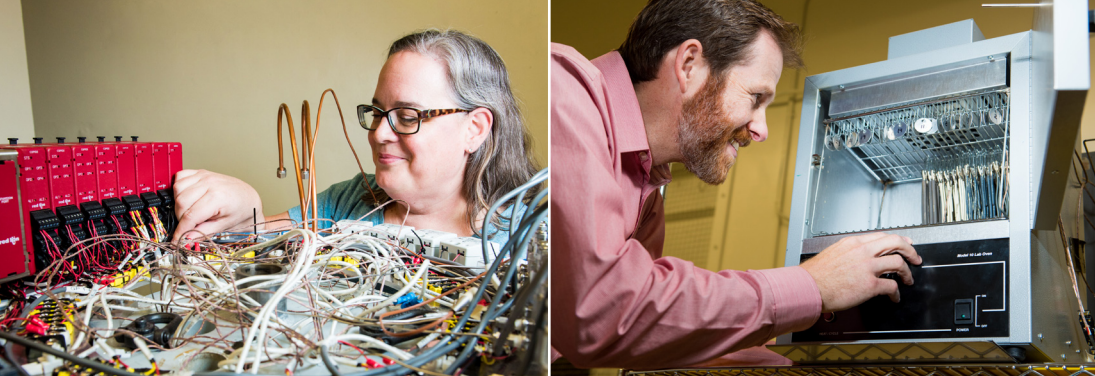
Lead Shielded Gamma Bunker

### BETA IRRADIATION FACILITY

- Uses include dosimeter and survey instrument calibrations, beta source calibrations, and radiation biology research
- Sources include  $^{90}\text{Sr}/\text{Y}$ ,  $^{85}\text{Kr}$ ,  $^{204}\text{Tl}$ , 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 in nuclides and energies
- Dose rates that range from background level to over  $5 \times 10^6$  rad/hr ( $5 \times 10^4$  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
- Irradiations of samples within various temperature and humidity environments, and for durations of minutes to many months.
- Digital imaging system, combined with wide energy range of photon fields, allows unique radiography capability for thin and thick items
- Most irradiations and calibrations are NIST/NVLAP accredited (Labcode 105020-0)

## DOSIMETRY LAB

- Houses four different types of radiation detection systems that cover most any application that requires measurement of radiation dose at locations external or internal to items
- Male and female anthropomorphic phantoms (RANDO®) for external beam dose studies, including radiation protection garments
  - Solid/Virtual Water phantoms and Well "re-entrant" Chamber for medical seeds



Anthropomorphic phantoms with internal cavities for thermoluminescent dosimeters (TLDs)

Alpha Continuous Air Monitors for Qualification Testing



## 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 (5x5x7 ft) capable of  $-40^{\circ}\text{C}$  to  $+50^{\circ}\text{C}$
- Medium environmental chamber (2x2.3x2.3 ft) capable of  $-60^{\circ}\text{C}$  to  $+200^{\circ}\text{C}$
- Small environmental chamber (1.6x1.6x1.6 ft) capable of  $-60^{\circ}\text{C}$  to  $+100^{\circ}\text{C}$
- 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

## CONTACT INFORMATION

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

U.S. DEPARTMENT OF  
**ENERGY**

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[www.pnnl.gov/radiation-measurement](http://www.pnnl.gov/radiation-measurement)