# Naturally Occurring Radioactive Material (NORM) – Uranium Mining

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# What is "Naturally Occurring Radioactive Material"?

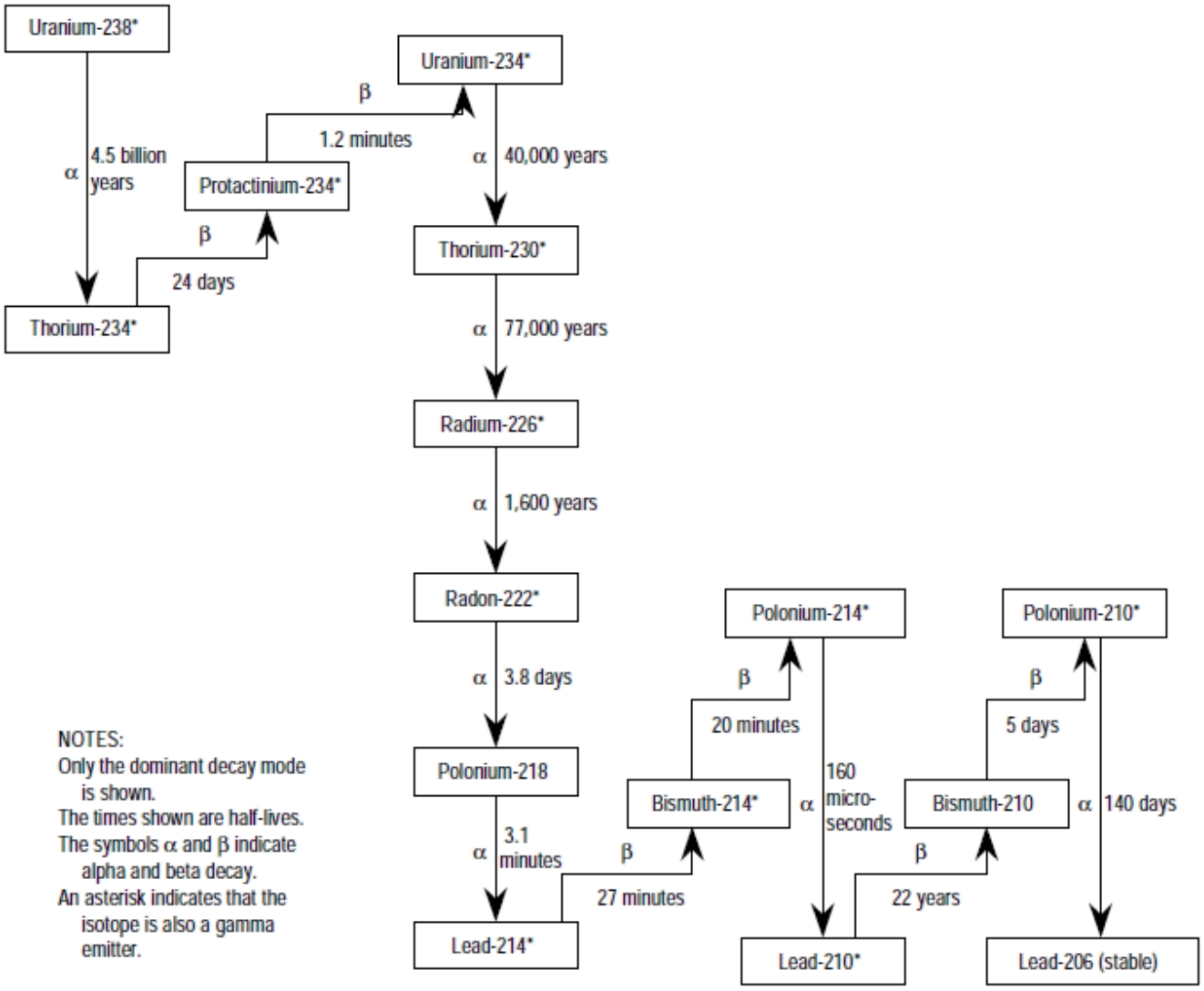
- Naturally occurring radioactive materials (NORM) are radioactive materials found in nature, formed by natural processes.
- Primordial (uranium, thorium, $K^{40}$)
- Cosmic ($H^3$, $C^{14}$, $Be^7$)
- Most NORM-bearing materials are not a health hazard.

# Naturally Occurring Radioactive Material

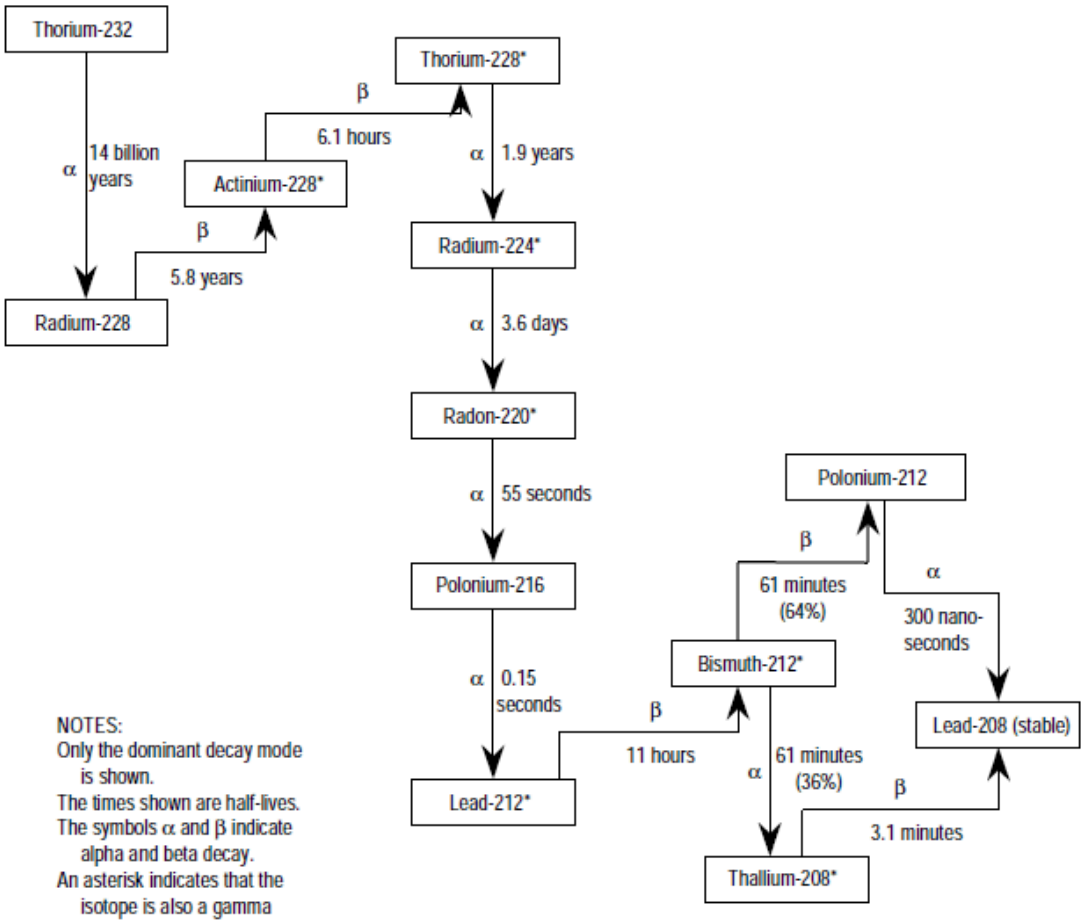
NORM originates in subsurface formations, which may contain radioactive materials such as Uranium and Thorium and their daughter products, Radium-226, Radium-228 and Radon-222.

Frequently, NORM is encountered in oil and gas exploration, development and production operations.

# U-238 Decay Series



# Th-232 Decay Series



# Naturally-Occurring Radioactive Materials (NORM)

- Radioactive materials which occur naturally and expose people to radiation occur widely, and are known by the acronym 'NORM'.
- Exposure to NORM is often increased by human activities, e.g., burning coal, making and using fertilizers, oil and gas production and uranium mining.
- Radon in homes is one occurrence of NORM which may need to be controlled, by ventilation *(only one method).*

# Difference Between NORM and TENORM

- NORM normally refers to $C^{14}$, $H^{3}$, $K^{40}$, $Be^{7}$, Uranium, Thorium, Radium, Radon
- Technologically enhanced naturally occurring radioactive materials (TENORM) are any naturally occurring radioactive materials whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities.

# Radiological effects caused by (NORM)

- It *depends* on the amount of NORM and the radionuclide in question.
- $C^{14}$, $H^{3}$, $K^{40}$, $Be^{7}$, Uranium, Thorium, Radium, Radon
- Exposure Pathway (eat, drink, breathe)
- Concentration Mechanisms
- Generally very minor.

# Example: Evaluation of Hazardous Waste Disposal Criteria for NORM/TENORM Waste

- Resource Conservation & Recovery Act (RCRA) Subtitle C facility, located 70 miles east of Denver, Colorado
- RESRAD Computer Code Used to determine allowable concentration of shipment waste.
- 2000 pCi/g (74 Bq/g) was limit determined in THIS evaluation.
- This is coincidentally the “limit” used to define radioactive waste in Colorado, U.S.A.

# Actual Question

- I am a field service technician in the submersible pump industry in Canada. We have been hearing more and more about NORM lately. Some of our technicians have been sent to well sites with Geiger counters. What levels are not going to be hazardous to our health? Our company has given us a course on NORM, but I would like a second opinion.
- International exposure standard is 20 mSv/y, plus ALARA
- Typically minor concern, but there may be exceptions!

# NORM is in Many Mineral Formations

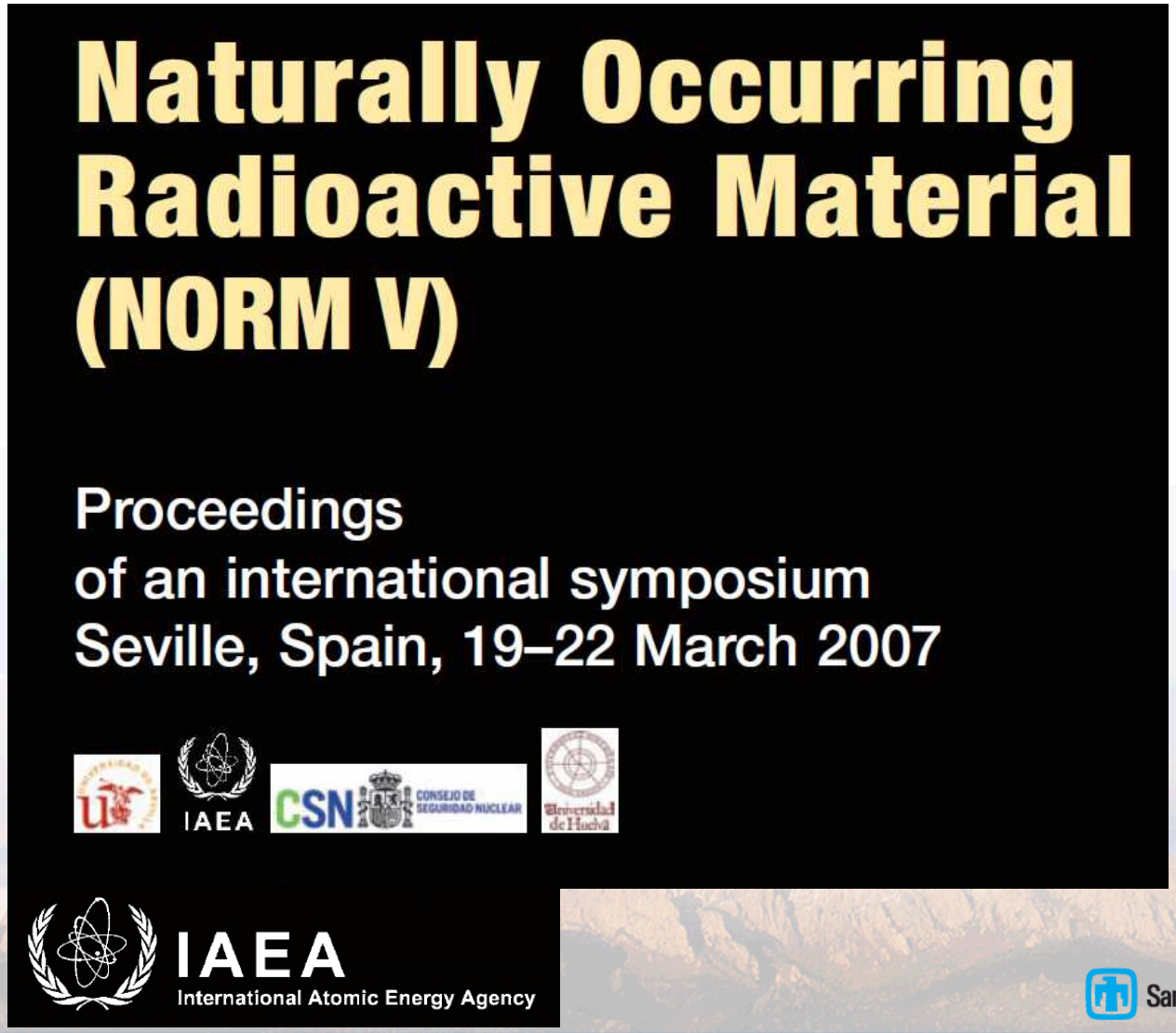
**EXECUTIVE SUMMARY**

**EPA 402-R-99-002**

**October 1999**

**Technologically Enhanced Naturally Occurring Radioactive Materials in the Southwestern Copper Belt of Arizona**

# International Debate on NORM Issues

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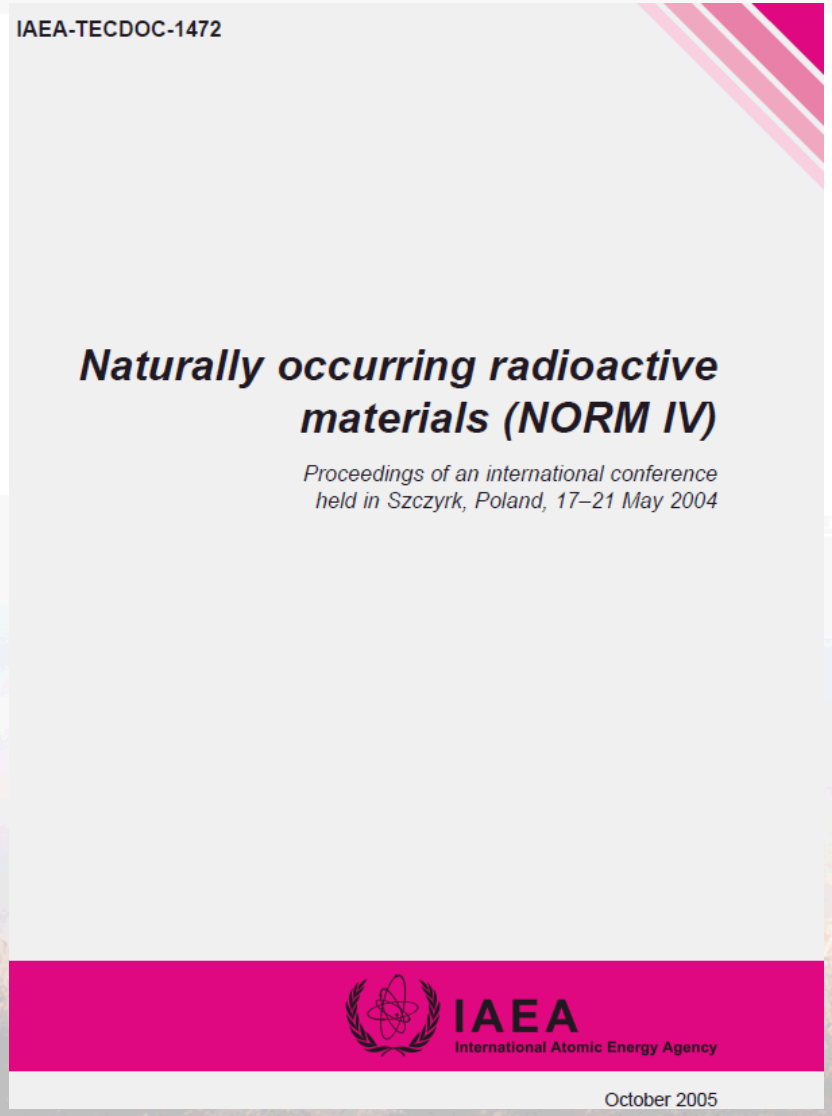
# International Debate on NORM Issues

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# NORM in Mineral Sands

- Australia and Africa are major producers of mineral sands containing titanium minerals and zircon.
- A by-product of this is monazite containing thorium, which is radioactive. Monazite is a minor constituent of many mineral sands deposits and is the main source of thorium.
- Appropriate occupational health provisions ensure safety in handling materials containing thorium.

# International Regulations

- Canada – Nuclear Safety and Control Act
- United States – Uranium Mill Tailings Control Act (UMTRCA)
- Australia – Australian Radiation Protection and Nuclear Safety Act 1998
- New Zealand – Minerals Programme for Minerals (Excluding Petroleum)
- IAEA –Long-term Stabilization of Uranium Mill Tailings IAEA-TECDOC-1403

# UMTRCA Summary

**1978 - Uranium Mill Tailings Radiation Control Act(42 USC 2022 et seq.)**

**UMTRCA amended the AEA by directing EPA to set generally applicable health and environmental standards to govern the stabilization, restoration, disposal, and control of effluents and emissions at both active and inactive mill tailings sites.**

**Title I of the Act covers inactive uranium mill tailing sites, depository sites, and vicinity properties. It directs EPA, the Department of Energy and the Nuclear Regulatory Commission to undertake the following:**

- **EPA must set standards that provide protection as consistent with the requirements of RCRA as possible. The standards must include ground water protection limits.**
- **DOE implements EPA's standards for the tailings piles and the vicinity properties**
- **provides perpetual care for some properties.**
- **NRC reviews completed site cleanups for compliance with EPA standards.**
- **licenses the site to the state or DOE for perpetual care.**

**Title II of the Act covers operating uranium processing sites licensed by the NRC. EPA was directed to promulgate disposal standards in compliance with Subtitle C of the Solid Waste Disposal Act, as amended, to be implemented by NRC or the Agreement States. The 1993 Amendments to UMTRCA further directed EPA to promulgate general environmental standards for the processing, possession, transfer, and disposal of uranium mill tailings. NRC was required to implement these standards at Title II sites.**

# International Standards

- Occupational Radiation Protection in the Mining and Processing of Raw Materials – Safety Standard Series No. RS-G-1.6
- Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium – Safety Series No. 27
- Management of Radioactive Waste from the Mining and Milling of Ores – Safety Guide No. WS-G-1.2
- Regulatory Controls of Radioactive Discharges to the Environment – Safety Guide No. WS-G-2.3
- The Application of the Principles for Limiting Releases of Radioactive Effluents in the Case of the Mining and Milling of Radioactive Ores – IAEA Safety Series No. 90, Vienna 1989

# International Standards

- ***Recent developments in uranium resources and production with emphasis on in situ leach mining – IAEA-TECDOC-1396***
  - **REGIONAL METALLOGENY: GEOLOGY OF URANIUM DEPOSITS**
  - **EXPLORATION: NEW PROJECTS**
  - **LICENSING**
  - **ISL MINING**
  - **HEAP LEACHING: IMPROVEMENT OF MILLING PROCESS**
  - **RESTORATION: ENVIRONMENTAL ISSUES**

# United States Resources

- **U.S. E.P.A. Website – Uranium Mines**
  - Overview
  - Extracting Uranium Ore
  - Radiation and Mining
  - Radiation and Milling
  - Who is Protecting You?
  - What You Can Do to Protect Yourself
  - Resources
- **U.S. E.P.A. Website – Uranium**
- **Colorado Uranium Recovery Regulations Summary**

# United States Resources

- Extraction and Beneficiation of Ores and Minerals - EPA 530-R-94-032, NTIS PB94-2008987
- 40 CFR 61 - Subpart B - National Emission Standards for Radon Emissions From Underground Uranium Mines
- FUSRAP Overview
- Federal, State, and Tribal Liaison Programs

# Other Resources

- **World Nuclear Association Website – What is Uranium? Why Does It Work?**

# Radiological and Non-radiological Impacts

**Short-term and long-term environmental impacts**

- **Environmental**
  - Surface water
  - Groundwater
  - Soils
  - Air
  - Radon
  - Flora
  - Fauna

# Radiological and Non-radiological Impacts

- Economic
- Social
- Technical
- Transportation
- Infrastructure
- Effects of accidents
- Other

# THE APPLICATION OF ADAPTIVE SAMPLING AND ANALYSIS PROGRAM (ASAP) TECHNIQUES TO NORM SITES
## Final Report - October 1999

- **Adaptive Sampling and Analysis Program (ASAP) data collection relies on real-time data collection technologies and in-field decision support to guide the course of characterization and/or remediation work. ASAP techniques have particular application to naturally occurring radioactive materials (NORM) problems because of the relative abundance of real-time technologies appropriate for radium-226. Included a gamma radiation detecting walkover/Global Positioning System (GPS) for complete surficial site coverage; *in situ High Purity Germanium (HPGe) gamma spectroscopy for quantitative isotope specific* direct measurements; and a sodium iodide (NaI)-based direct measurement device called RadInSoilTM, specifically intended for NORM work.**

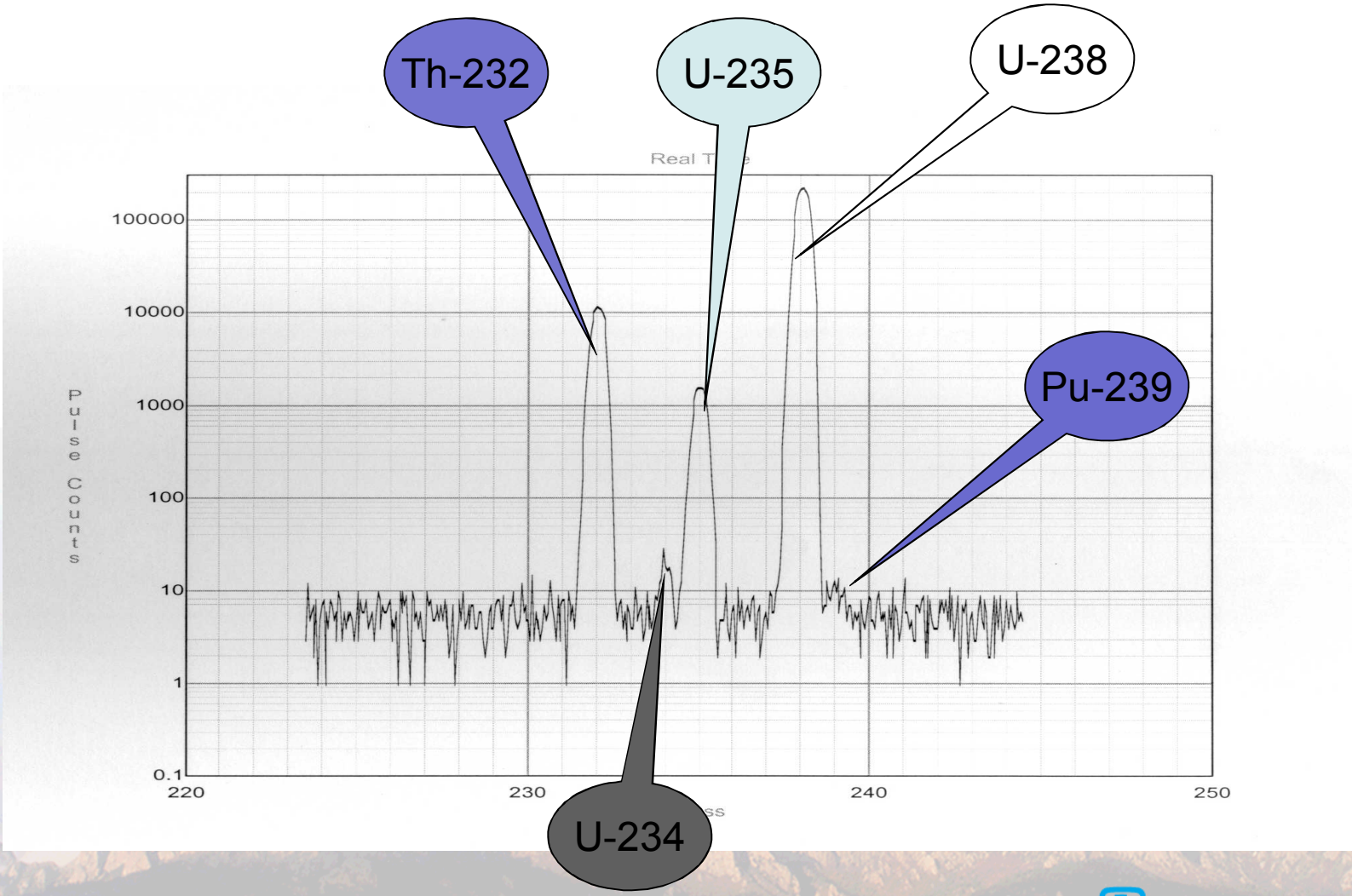
**DOE/BC/W-31-109-ENG-38-9**

**(OSTI ID: 14169)**

# Non-radiometric Assay of NORM

- Even though NORM is radioactive, it has LONG half-lives but LARGE atomic number
- LARGE atomic number lends itself to ICP-MS (or other non-radiometric assay)
- Advantages: Low detection limits and accurate isotope ratios for long-lived isotopes

# Example Spectrum (DOE-EML Test Filter)



# Summary

- **NORM is natural (*naturally occurring radioactive material*).**
- **Man can inadvertently CONCENTRATE it (TENORM)**
- **Being aware of it, we manage it accordingly.**
- **Exercise ALARA**
- **Typically, relatively minor risk.**
- **Both radiometric & non-radiometric methods of assay**