Radioisotope Production at the USGS Research Reactor

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Brief History of Reactor

- Construction decision in 1967
- Startup in February, 1969
- Initial research centered around neutron activation analyses
- Samples were mostly water and geologic materials
- By 1980's the following research techniques had been added to the reactor capabilities
  - Delayed neutron analyses for U and Th
  - Neutron-induced fission track studies
  - Argon geochronology

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Brief History of Reactor

- In the 1990's an 8" diameter vertical beam tube was added
- Industrial-use isotope production was started.
- In 2007 Colorado School of Mines started using the reactor for research and teaching.
- ~ 475,000 sample irradiations done since 1969
- New facility capabilities being developed include improved gamma ray spectroscopy and neutron radiography

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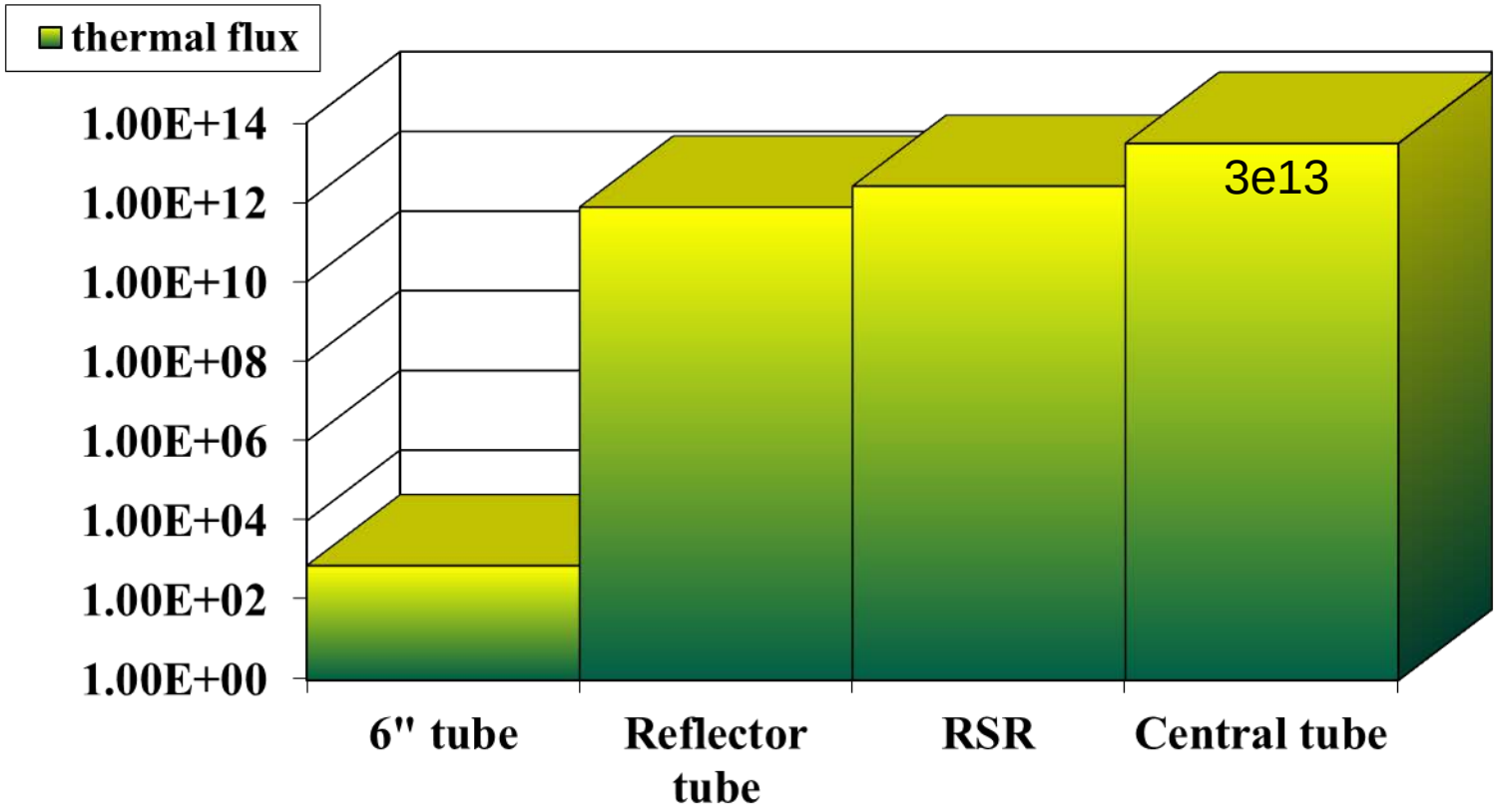
Reactor = source of neutrons



Neutron Flux Levels (n/cm^2-s)

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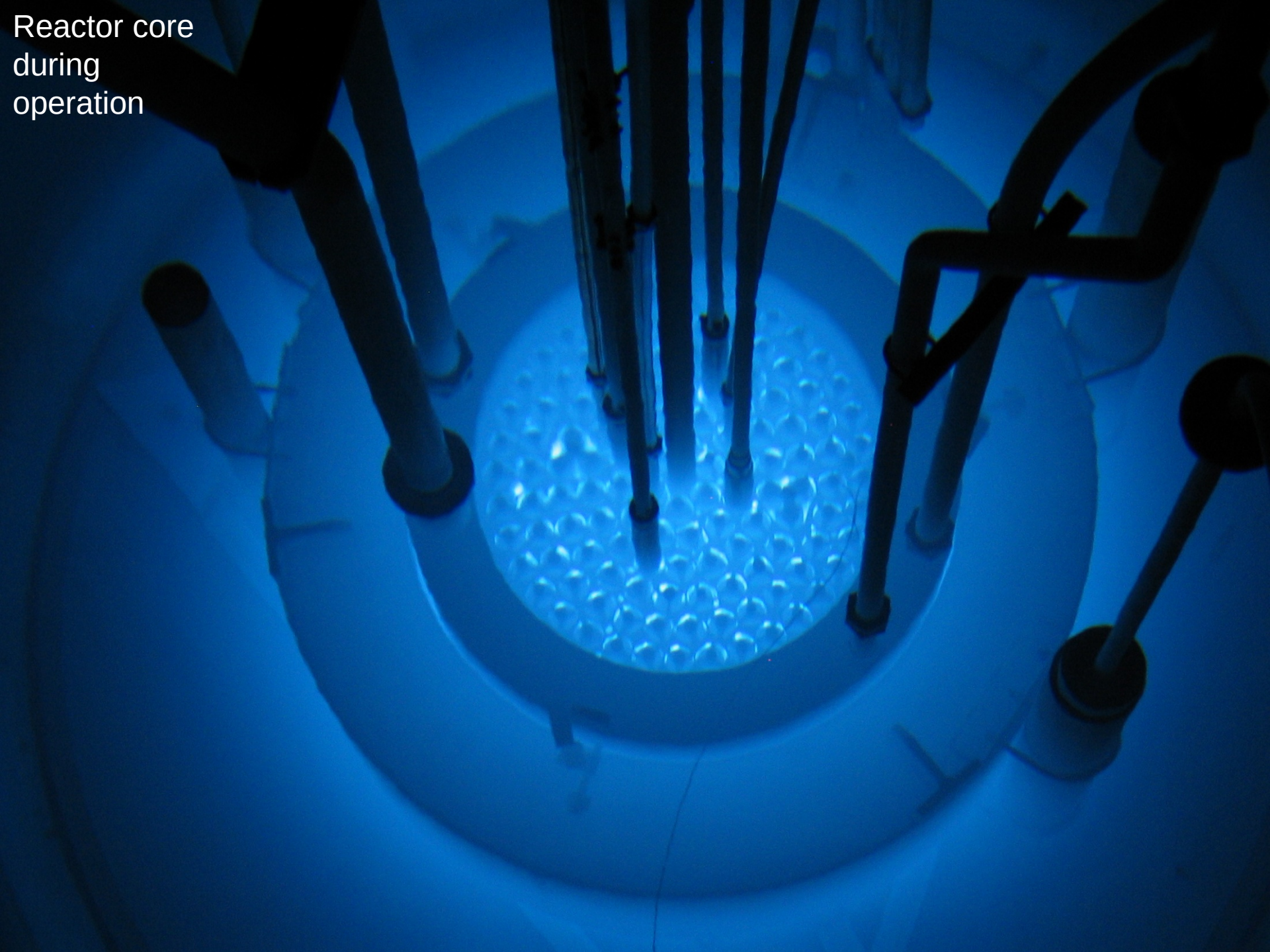
Reactor core
during
operation

USGS Reactor Control Console

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Isotope Production

- Industrial isotope production
  - Isotopes are produced as gases, liquids, & solids
  - Isotopes are relatively short-lived (half-lives from 1.6 hr to 115 days)
  - Radiography sources – ^{24}Na for large component penetration
  - Microspheres – simulate sand of various sizes
  - Amount produced per project ranges from a few milliCuries to ~3 Curies
  - The facility makes ~4 radioactive shipments/week
  - Reactor staff are certified radioactive material shippers and one hazmat-CDL driver is on staff

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Isotope Production

- Isotope production for research and industrial use is routinely performed:

Radioisotope	**Half-life**	**Form**	**Use**
Na-24	15 h	liquid or solid	radiography, tracer
Ar-41	1.8 h	gas	tracer
Sc-46	84 d	solid	tracer
Br-82	35 h	liquid or solid	tracer
Sb-124	60 d	solid	tracer
La-140	1.7 d	liquid or solid	tracer
Ta-182	115 d	solid	density gauge source
Au-198	2.7 d	solid	tracer
Fission products	varies	solid	tracer, isotope studies

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Isotope Production - Examples

- Radioisotope production for Colorado State University to study decontamination techniques of livestock was recently performed
- Tracer isotopes for use in the petroleum industry are routinely produced
- Possible research on medical radioisotope production is planned for the future
  - Work to be done in cooperation with Colorado School of Mines and medical researchers
  - Isotopes will be for diagnostic & therapeutic use

~32 Ci of radioisotopes shipped in 2014

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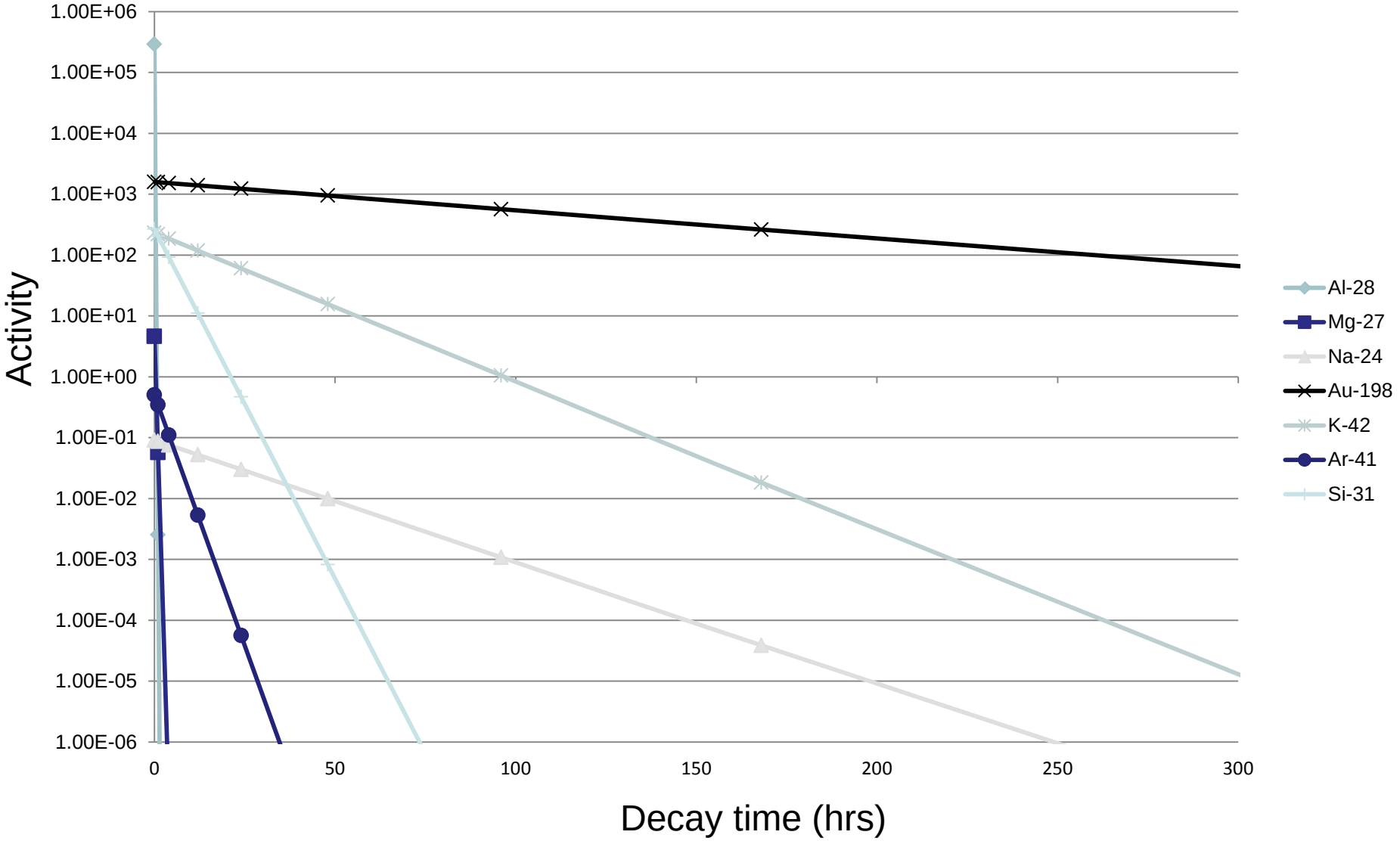
Isotope Production Example

(Goal was product with >99.99% Au-198)



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Gamma Spectroscopy

- Facility has four gamma spectrometers for nuclide identification and quantification
- Isotope production samples are tested to verify target purity and activation levels
- Radioactive shipments are checked for content and regulatory compliance
- Reactor-activated materials and passive (naturally-occurring) radioactive materials are analyzed

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Major Reactor Use: Neutron Activation Analysis

- Atoms in sample capture neutrons to produce radioisotopes that emit gamma rays
- Sample is analyzed to determine energy and quantity of gamma ray emissions
- Radioisotopes are identified, allowing calculation of original sample's elemental composition (quantitative and qualitative)
- Process is nondestructive and requires no chemical processing

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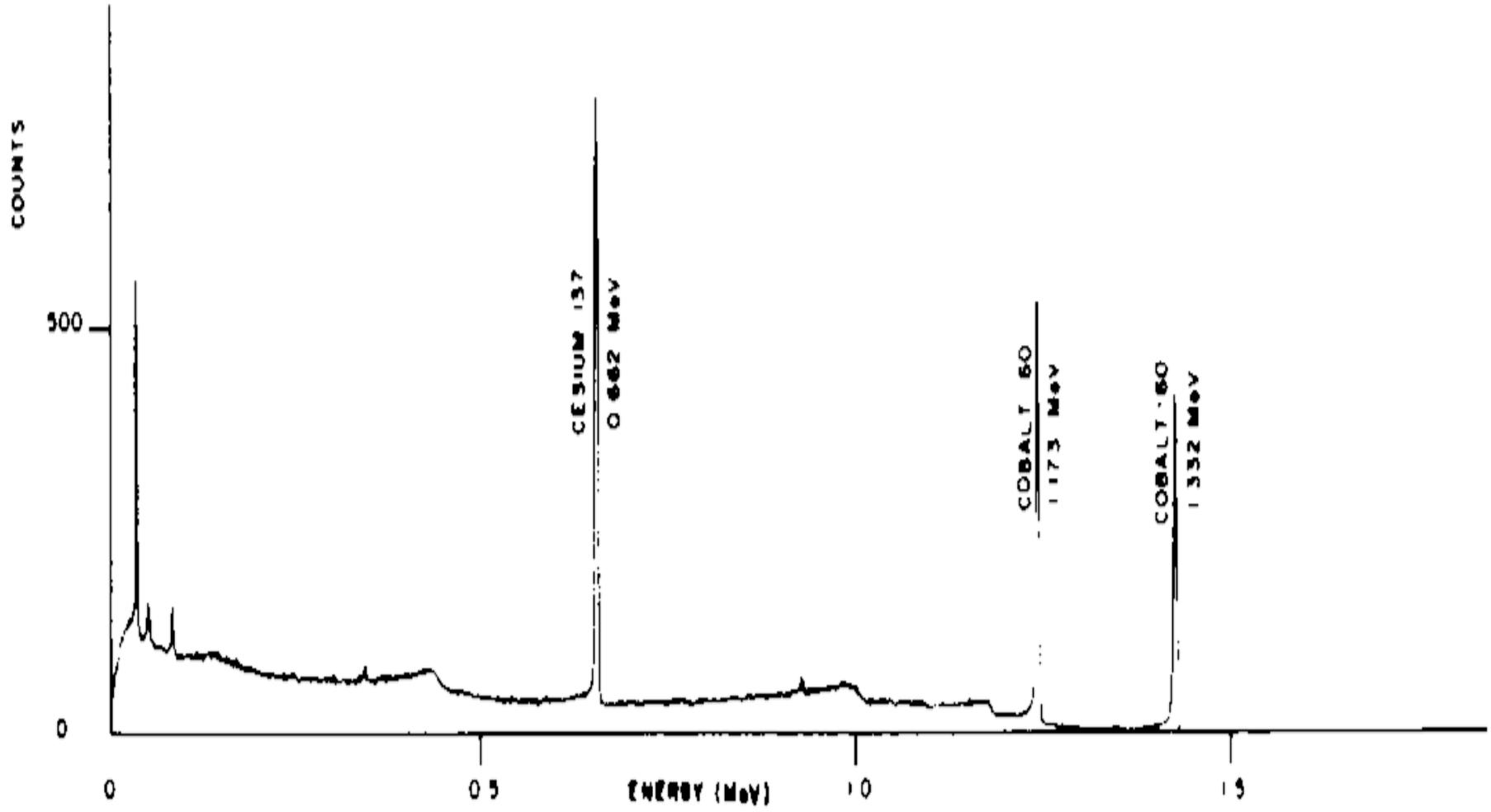
Neutron Activation Analysis Gamma Spectrum



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Typical Detection Limits

Sodium	3.1 ppm	Nickel	1.0 ppm
Strontium	8.1 ppm	Zinc	0.5 ppm
Cesium	0.01 ppm	Arsenic	0.1 ppm
Barium	4.3 ppm	Antimony	0.04 ppm
Uranium	0.02 ppm	Cobalt	0.02 ppm
Lanthanum	0.02 ppm	Chromium	0.5 ppm
Samarium	0.002 ppm	Holmium	0.1 ppm
Zirconium	4.5 ppm	Tantalum	0.002 ppm
Tungsten	0.25 ppm	Gold	0.001 ppm

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Questions?

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