OAK RIDGE National Laboratory

~~November 6, 2025~~
January 9, 2026 | Nuclear Data Week “2025”

Activation Library Use in Target Design and Analysis for Radioisotope Production

William (B.J.) Marshall

Radioisotope Science and Technology Division

U.S. DEPARTMENT of ENERGY

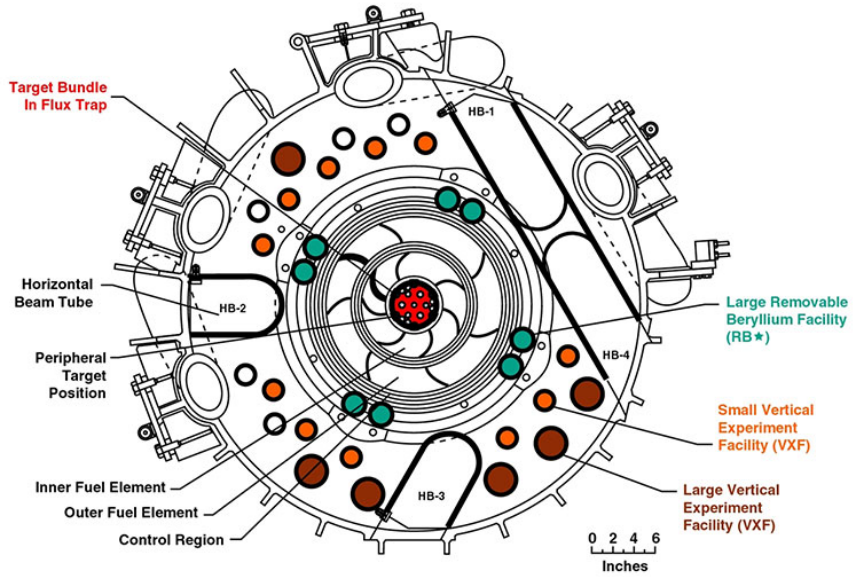
ORNL IS MANAGED BY UT-BATTELLE LLC
FOR THE US DEPARTMENT OF ENERGY

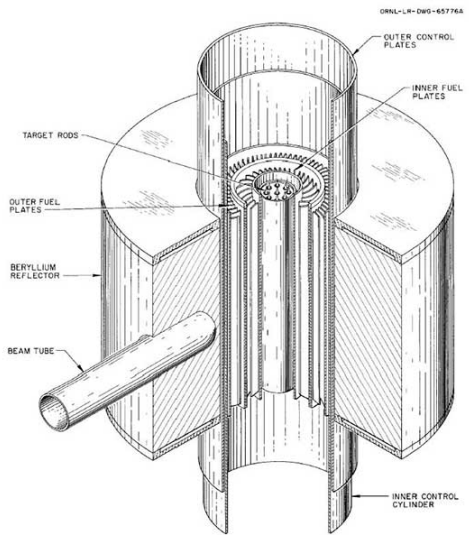
Outline

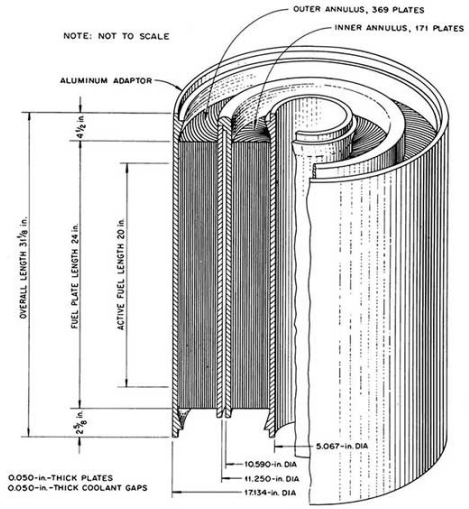
- HFIR description and operations
- Radioisotopes produced at HFIR
- Codes, tools, and data
- Conclusions

High Flux Isotope Reactor (HFIR) description and operations

- HFIR is a unique research reactor
  - Central flux trap intended for transplutonium production
  - Beryllium reflector with numerous irradiation facilities
  - Beam tubes for neutron scattering
- Cylindrical core approximately 2’ (~60 cm) tall and 15” (~38 cm) outer diameter
  - 5” (12.7 cm) OD for central flux trap
- 85 MW thermal power, ~23 day cycles
  - Peak thermal flux ~2×10^{15} n/cm^2 s in flux trap
  - Thermal flux in the reflector ranges from about 5×10^{14} to 1×10^{15} n/cm^2 s

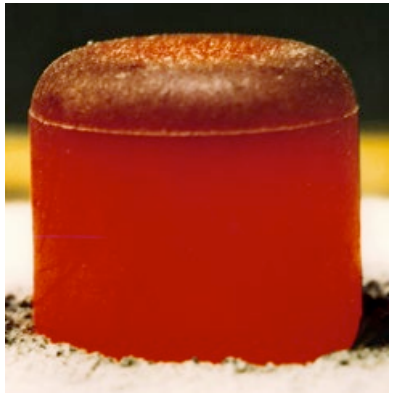






Radioisotope products

- ^{252}Cf: Part of the original and still primary mission of HFIR for the DOE Isotope Program
  - Generated in the flux trap from Cm target material provided by Savannah River
- ^{238}Pu: Heat source for NASA RTGs
  - $^{237}NpO_2$ feed material from INL originally generated at Savannah River
  - Irradiation for multiple cycles in the Be reflector
- Anything else DOE Isotope Program desires
  - Industrial sources for radiography and other applications
  - Medical sources for therapy, diagnostics, or both



Target design, analysis, and qualification radiation transport tools

"Fit-for-purpose" or "Low-fidelity" tools

- TCOMP
  - Prediction of ^{252}Cf production
  - Nuclear data have been tuned to give accurate predictions based on past campaigns
- ISOCHAIN
  - Simplified, user-friendly code for approximate activation and decay calculations
  - Nuclear data derived from "Lockheed Martin" Chart of the Nuclides or input by user

These tools do not directly use released, evaluated nuclear data.

"General purpose" or "High-fidelity" tools

- MCNP/ORIGEN
  - Flux tally from static MCNP calculation input to ORIGEN for activation and decay calculation
  - LANL-generated ACE data for MCNP and ORNL-generated AMPX data for ORIGEN
- HFIRCON
  - Coupling of MCNP with ORIGEN to do cycle simulation including depletion, activation, decay, heat generation

In both standalone ORIGEN and HFIRCON, the JEFF-3.0 activation library is the primary source of nuclear data for depletion and activation.

Conclusions

- Radioisotope production calculations would benefit from a new activation library, especially if it is consistent with ENDF data used in transport calculations
- ORNL radioisotope production predictions and measurements may be helpful in providing validation for activation library evaluations
- Other HFIR users may also be able to provide feedback
  - Neutron activation analysis laboratory
  - Fuel irradiation
  - Other materials irradiations

Thanks for your time and attention!