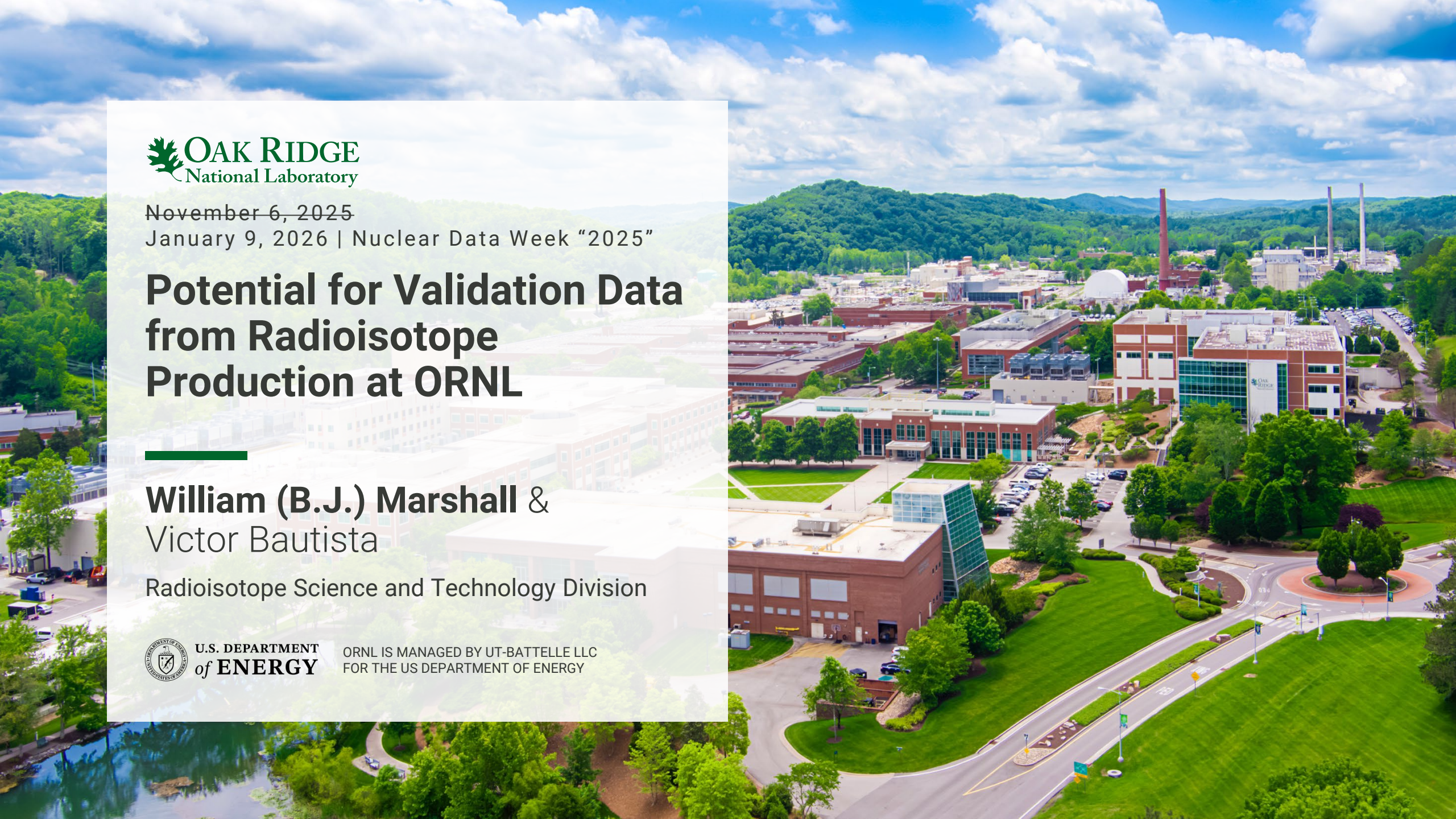

OAK RIDGE National Laboratory

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Potential for Validation Data from Radioisotope Production at ORNL

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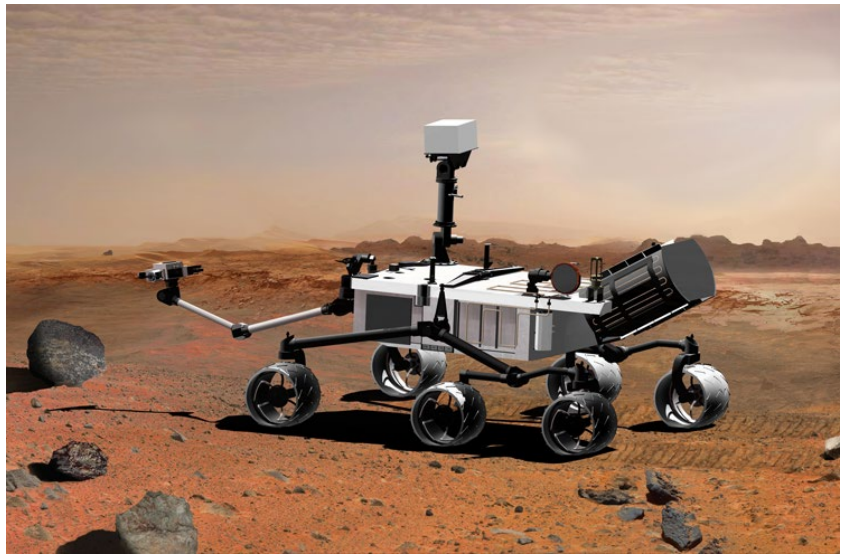
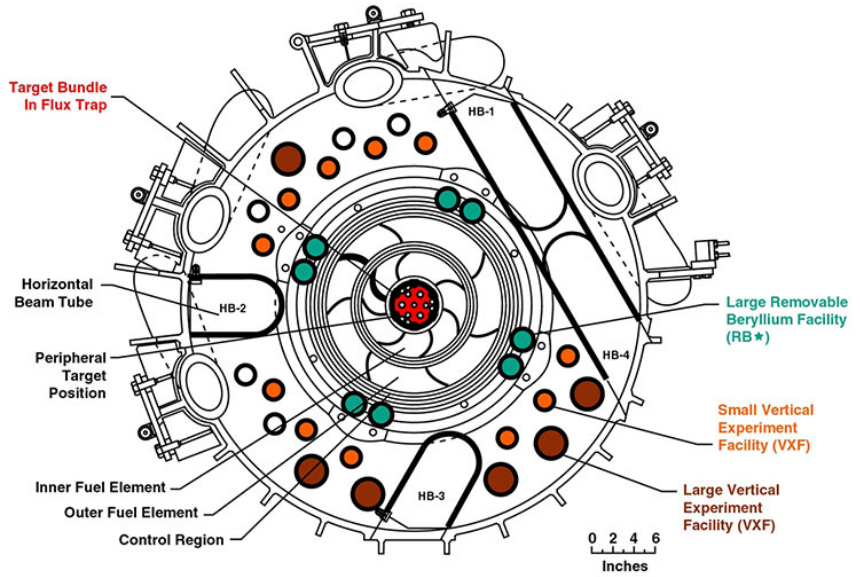
Outline

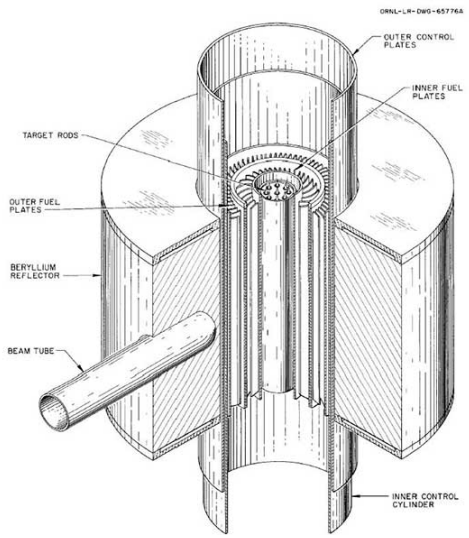
- HFIR description and operations
- Potentially relevant codes and tools
- Unknowns and uncertainties that need to be quantified
- Example data
- Conclusions

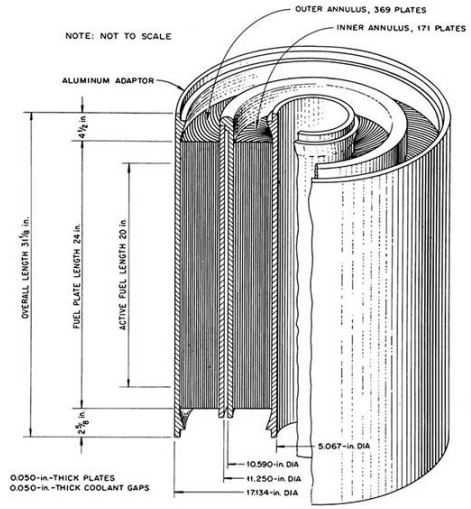


High Flux Isotope Reactor (HFIR) description and operations

- 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







Potentially relevant codes and tools

- High-fidelity modeling and simulation for radioisotope production uses combinations of MCNP and ORIGEN
  - Many calculations performed explicitly with MCNP flux tally input to standalone ORIGEN calculation
  - HFIRCON couples an ORNL variant of MCNP5 with MSX_DEPLETE, a variant of ORIGEN
- MCNP calculations can obviously use any ACE-formatted data
- ORIGEN defaults to JEFF-3.0/A library but other data can be used
- HFIRCON defaults to ENDF/B-VII.1 data
- Other low-fidelity tools are used for specific nuclides (^{252}Cf) or for scoping

Unknowns and uncertainties

- Operational uncertainties need to be quantified and propagated
  - Power level, flow rate, temperature distributions, etc.
- The impact of typical assumptions needs to be investigated
  - Other experiments/targets are typically neglected
  - MCNP/ORIGEN typically assumes beginning of cycle control cylinder positions
  - Typically assume room temperature nuclear data
  - Flux tallied in 56, 238, or 252 groups
- Chemical processing losses and process variability are not well understood by the radiation transport staff

Potential strategies to address unknowns and uncertainties

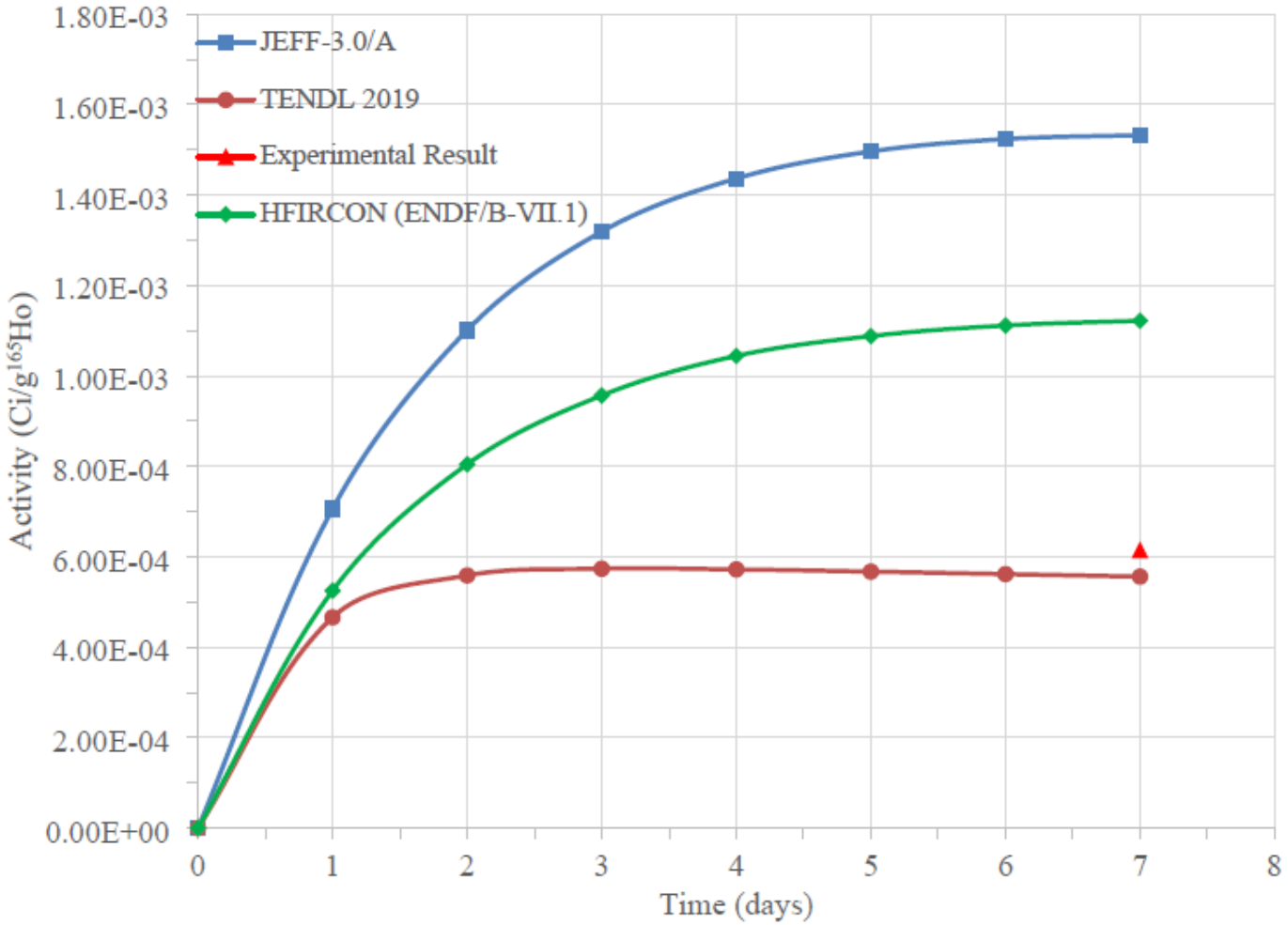
- Neutron activation analysis laboratory uses one of the vertical experiment facilities in the permanent Be reflector
- Irradiation of flux monitors in various locations in multiple campaigns over the years – ideally also in new permanent Be reflector after installation
- Develop better, deliberate communication with chemistry groups to enhance understanding of measured quantities and associated uncertainties
- Integration of thermal-hydraulic analyses with respect to temperatures

In summary, the process to quantify uncertainties and demystify unknowns is a combination of measurements and analyses, modeling and simulation, and improved communication.

Example data: ^{166m}Ho (1/2)

- Prediction of specific activity of ^{166m}Ho produced in HFIR flux trap was 1.32 mCi/g
- Measured specific activity was 0.61 mCi/g
- Investigation identified widely varying ^{166m}Ho(n, γ)^{167}Ho cross sections among Mughabghab, JEFF-3.0/A, TENDL-2019, and ENDF/B-VII.1
- Calculations with JEFF-3.0/A, TENDL-2019, and ENDF/B-VII.1 indicate TENDL-2019 yields closest prediction
  - Plot on next slide
- See ORNL/TM-2023/3208 for more details

Example data: ^{166m}Ho (2/2)



Conclusions

- Radioisotope production calculations and measurements represent an untapped source of validation data for nuclear data evaluation
- A significant amount of uncertainty and process quantification is needed to improve the utility of these data
- There is interest at ORNL in developing and executing the necessary program to perform this quantification, though funding is currently uncertain
- Potential for a future stream of validation data to support evaluations for radioisotopes of programmatic interest to the DOE Isotope Program

Thanks for your time and attention!