OAK RIDGE National Laboratory

Impact of Nuclear Data on Advanced Energy Systems Safety and Operation

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ORNL is managed by UT-Battelle, LLC for the US Department of Energy

U.S. DEPARTMENT OF ENERGY

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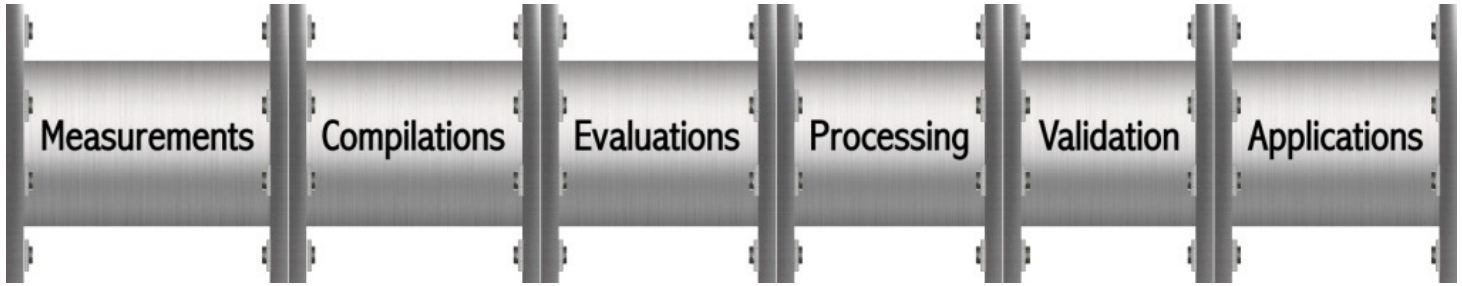
Overarching Goal of this project

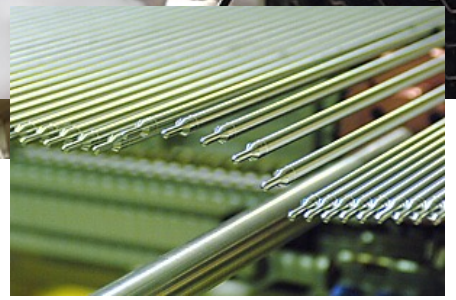
- **Facilitate identifying** nuclear data deficiencies and needs in the US Nuclear Data Program databases that have the most impact on advanced nuclear energy systems' safety and operation
- **Develop resources** for enabling end-user-driven, application-driven improvements in the nuclear data pipeline to address these needs



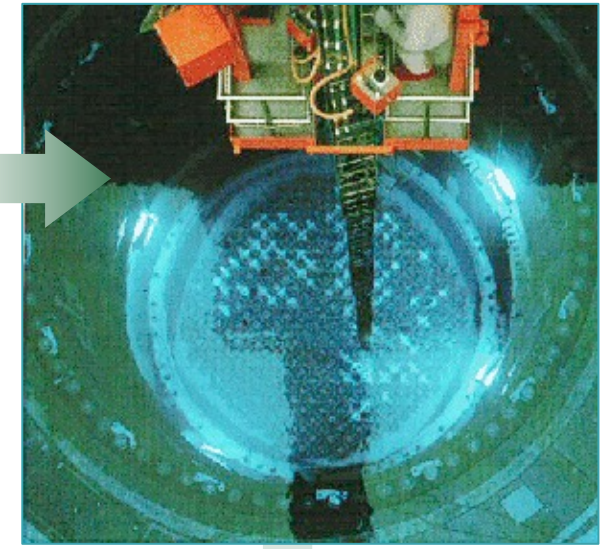
Significance to Stakeholders

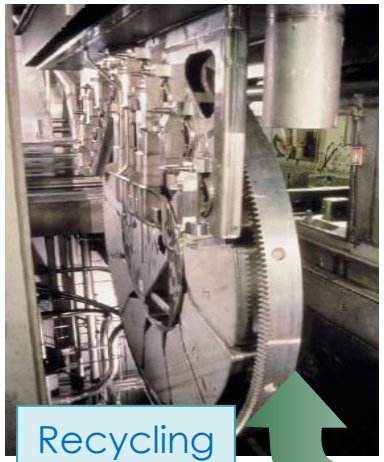
- **From blueprints to reality**: benefitting from DOE support, US private industry is actively engaged in designing next generation nuclear technologies
- **Development and deployment of advanced nuclear energy systems**: critical for meeting growing domestic demands for energy security and clean energy, and for ensuring global competitiveness
- **Understanding and quantifying the impact of nuclear data** and nuclear data uncertainties is essential for:
  - ensuring optimal design of advanced reactor concepts and safe operation of deployed advanced reactors
  - designing and safely operating the storage, transportation, and disposal systems for the used fuel that is discharged from these reactors

Material processing and fuel fabrication



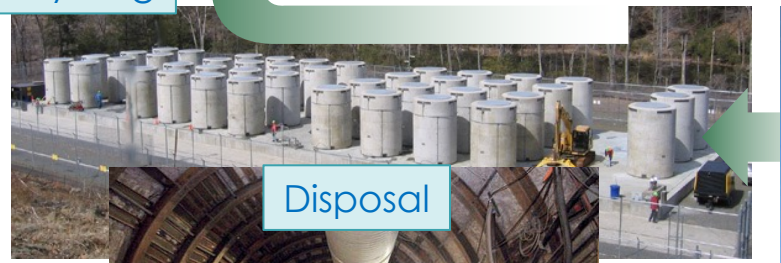
Commercial and research reactors



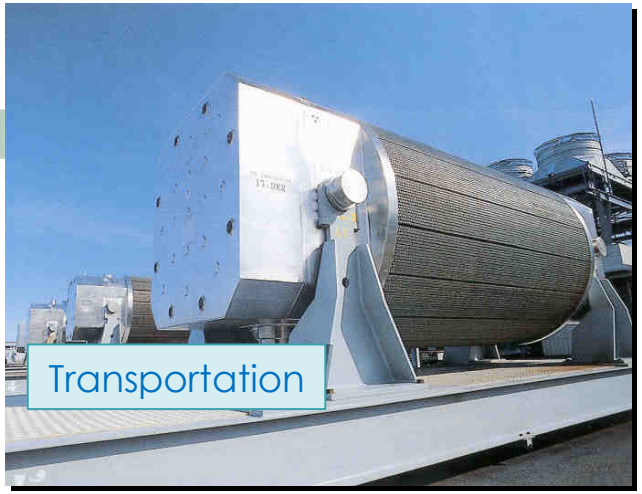


Recycling

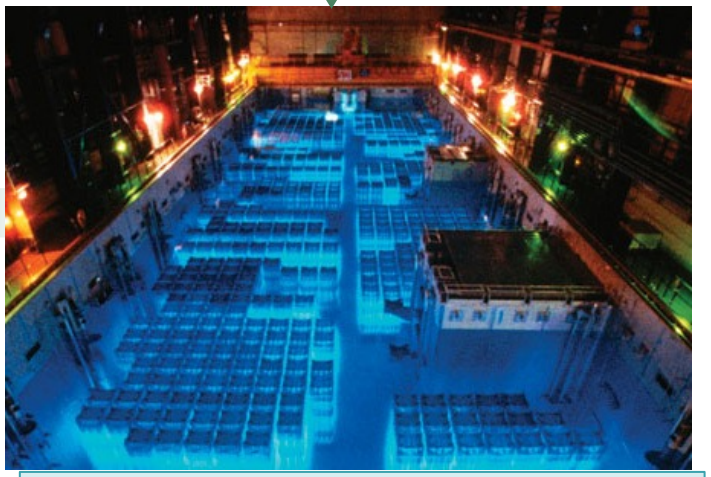
Nuclear Data are the bedrock of M&S front-end to back-end



Disposal



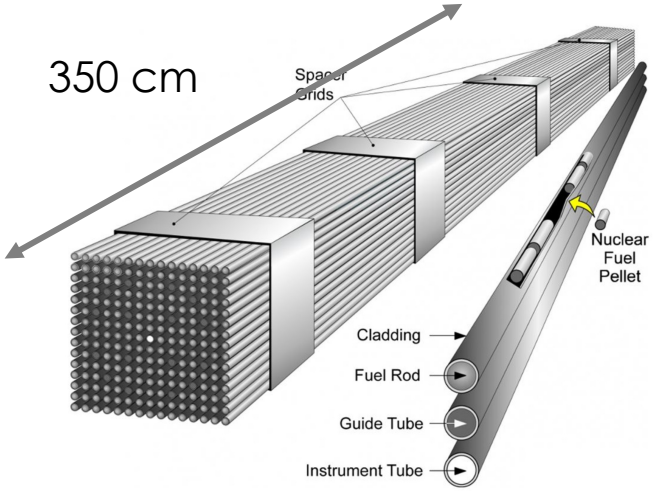
Transportation



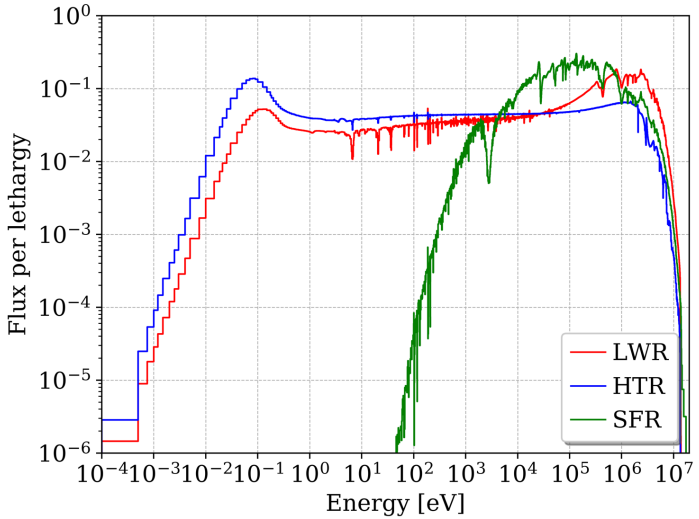
Storage, safeguards, and security

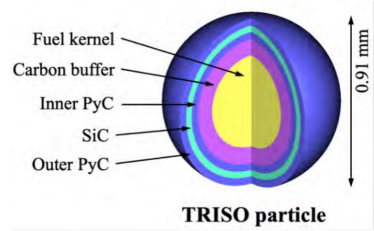
Advanced reactor technologies are significantly different than LWRs

Different materials (fuel, coolant), different concepts, different physics behavior

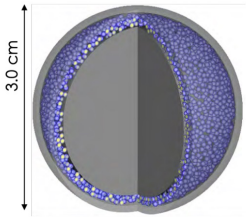


LWR fuel assembly





TRISO particle

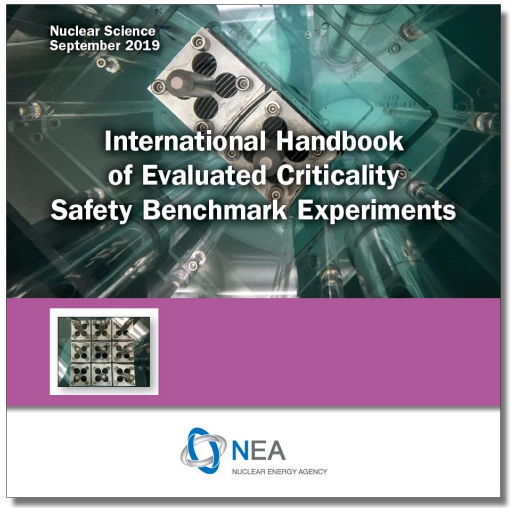


FHR fuel pebble

Different needs and requirements for applied computational tools and nuclear data

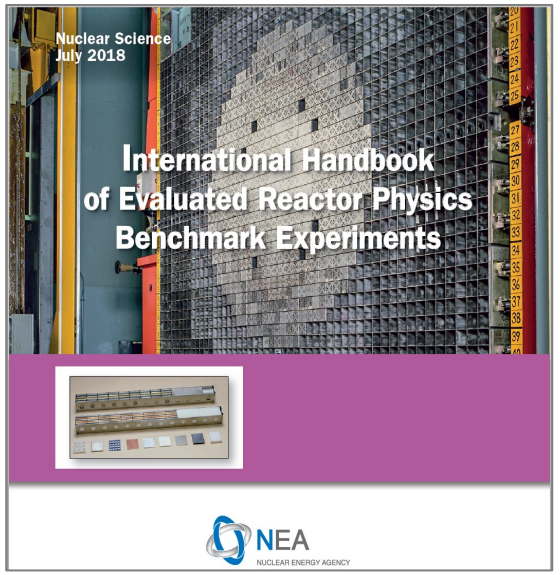
Resources to assess nuclear data impacts for advanced reactors are very limited compared to LWRs

A large diversity of resources and knowledge documented over the past 60 years of commercial operational and experimentation is available for LWR assessments.



over 600 criticality benchmarks

over 160 reactor benchmarks



Seven IRPhE benchmarks are relevant to advanced reactors configurations. None of them include measurement data for **reactor key metrics as a function of fuel burnup during reactor operation.**

Clear need for a benchmark model resource to assess nuclear data impacts for advanced reactors beyond integral metrics like k_{eff} and beyond fresh fuel

Steps towards achieving the overarching goal

1. Formulate extended advanced reactor benchmark models with irradiated fuel → **Benchmark model resource to assess nuclear data impacts as function of fuel burnup**
2. Assess nuclear data impacts for advanced reactor key metrics and develop sensitivity coefficients of key nuclides and nuclear data → **Sensitivity data file (SDF) resource**
3. Investigate nuclear data needs for advanced reactors by quantifying uncertainties of key metrics due to nuclear data uncertainties → **Key metrics uncertainty resource**

4. Demonstrate approach to improve critical steps in nuclear data pipeline, for rapid testing and evaluation of NNDC nuclear data and associated data processing tools

(1) Formulate extended advanced reactor benchmark models with irradiated fuel

- Extend to different fuel burnups, beyond first criticality or a single state point, existing evaluated and theoretical benchmark models that are representative of four high priority advanced reactor technologies and for different neutron flux spectra

Reactor technology	Benchmark name/type	Fuel/moderator/coolant
Pebble-bed HTGR (thermal)	HTR-10 /experiment	UO_2/graphite/He
SFR (fast)	EBR-II / experiment	HEU/-/Sodium
Pebble-bed FHR (thermal)	FHR / computational	UCO/graphite/FLiBe
Molten chloride MSR (fast)	MCFR / computational	UCl_3-NaCl/ MgO/ fuel serves as coolant

Impact

- **Establish a comprehensive assessment resource** that is needed for evaluating and quantifying the impact of nuclear data and nuclear data uncertainties on advanced nuclear energy systems' safety and operation
- **Enable identifying** nuclear data deficiencies and strengthening the effectiveness of the US Nuclear Data Program databases and ENDF/B's quality assurance system
- **Support the nuclear data evaluators** in improving the effectiveness and efficiency of the toolsets and resources that are used as a basis for thoroughly testing, evaluating, and validating any ENDF/B release
- **Outcomes and benefits of this research will go beyond nuclear data** for advanced reactors systems and will facilitate overcoming other existing challenges in applied nuclear science, nuclear energy, isotope production, and national security and non-proliferation
- **All created resources will be made publicly available** to benefit the nuclear data science and nuclear energy communities, and to support academia in fostering learning and further research

Acknowledgments

- This is a new project, FY24 – FY26, collaboration ORNL-BNL
- We appreciate the funding and support of this project by the DOE Nuclear Data Program

Questions ?