

# New $^{90,91}\text{Zr}$ Zirconium Evaluations

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# Motivation for New Stable Zirconium Isotope Evaluations

**Timeline:** New evaluations and validation to be completed in **early/mid 2026.**

**Introduction:** Zirconium is used as cladding for uranium fuel rods and zirconium hydride is being developed as an advanced moderator.

**Current Zirconium Evaluation Deficiencies & New Experimental/Theoretical Developments are summarized below.**

Zirconium evaluations miscalculate ICSBEP benchmarks by up to ~400 pcm beyond experimental uncertainties.

## Resolved Resonance Region

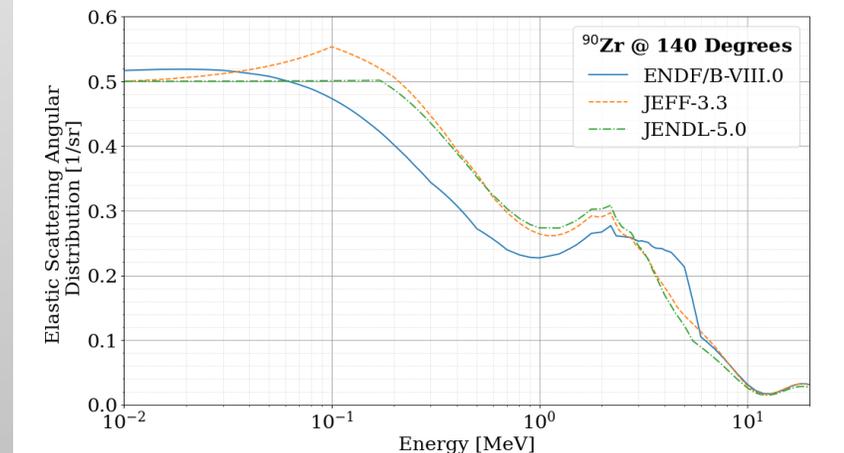
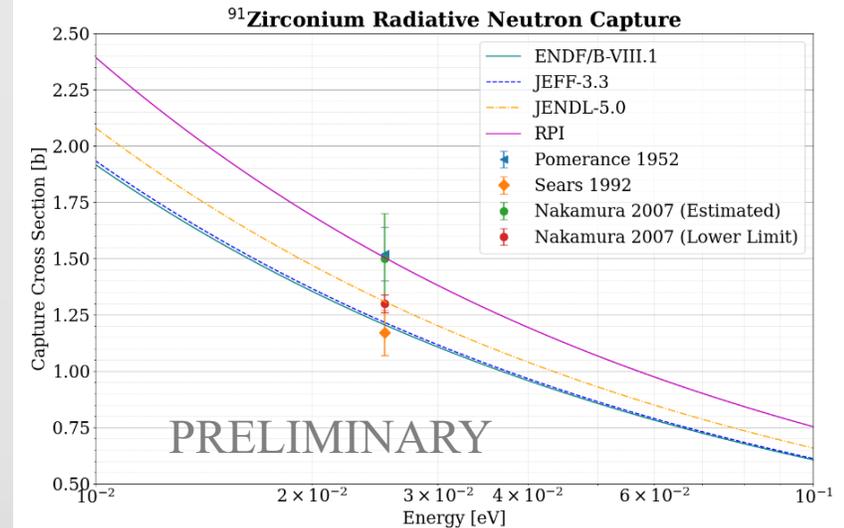
1. New high eV -> keV transmission and capture data from ORNL/GELINA<sup>[1][2]</sup>
2. Several resonances in current ENDF/B disagree with available measurements
3. Large thermal cross section differences between libraries
4. Current ENDF/B evaluation in MLBW and provides limited to no covariance data

## High Energy Region

1. Several new measurements available: total cross section<sup>[3]</sup>, (n,2n), DT leakage spectra<sup>[4]</sup>, etc.
2. RPI quasi-differential scattering data demonstrate need for improvement of elastic scattering angular distributions below 2 MeV<sup>[5]</sup>
3. Several updates made to OPTMAN since last ENDF/B evaluation
4. New soft-rotor (RIPL 609) and rigid-rotor (RIPL 611) optical developed for even and odd Zr isotopes, respectively<sup>[6]</sup>

1. Brown, J et al. "Zirconium Nuclear Data Campaign: Measurement of  $^{90}\text{Zr}(n,\gamma)$  cross section" *EPJ Web of Conferences* **284**, 01011 (2023)  
 2. Guber K. and Brown, J. "ORNL Neutron Cross Section Measurements of Zr-isotopes" *NCSP Technical Program Review*. Santa Fe, NM, USA (2025)  
 3. Rapp, M.J. et al. "Tantalum, Titanium, and Zirconium Neutron Total Cross-Section Measurements from 0.4 to 25 MeV", *Nuclear Science and Engineering*, **193**, no. 8, pp. 903-915 (2019)

4. Zhang, S. et al. "Measurement of leakage neutron spectra from zirconium with D-T neutrons and validation of nuclear data" *Fusion Engineering and Design*, **149**, 111311 (2019)  
 5. Siemers, G. et al. "Zirconium Scattering Sensitivity in Neutron Transport Calculations of Multiplying Systems" Workshop for elastic and inelastic neutron scattering, Troy, NY, USA (2023)  
 6. Capote, R. et al. "RIPL - Reference Input Parameter Library for calculation of nuclear reactions and nuclear data evaluations" *Nuclear Data Sheets* **112(3)**, 3107-3214 (2009)



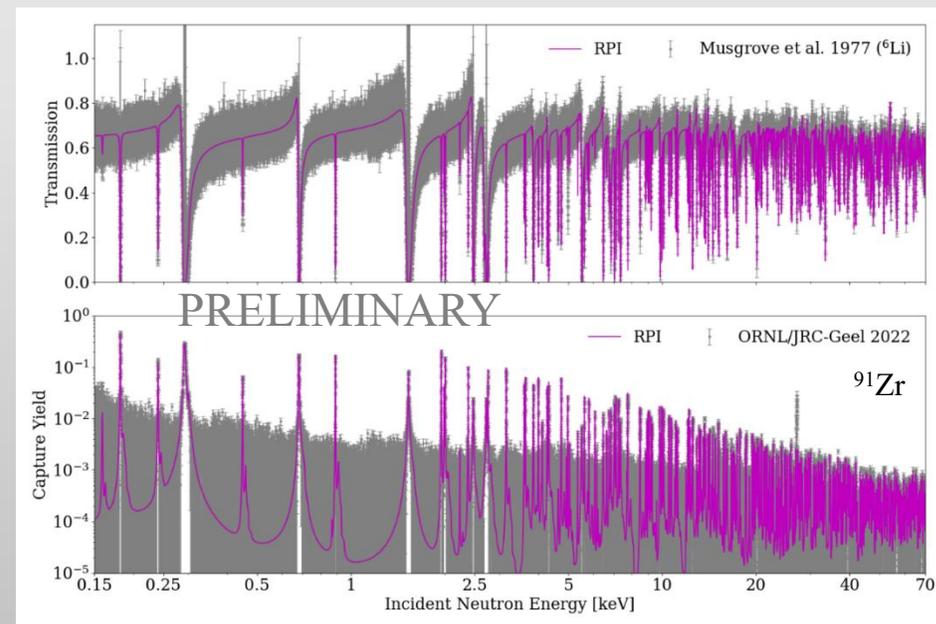
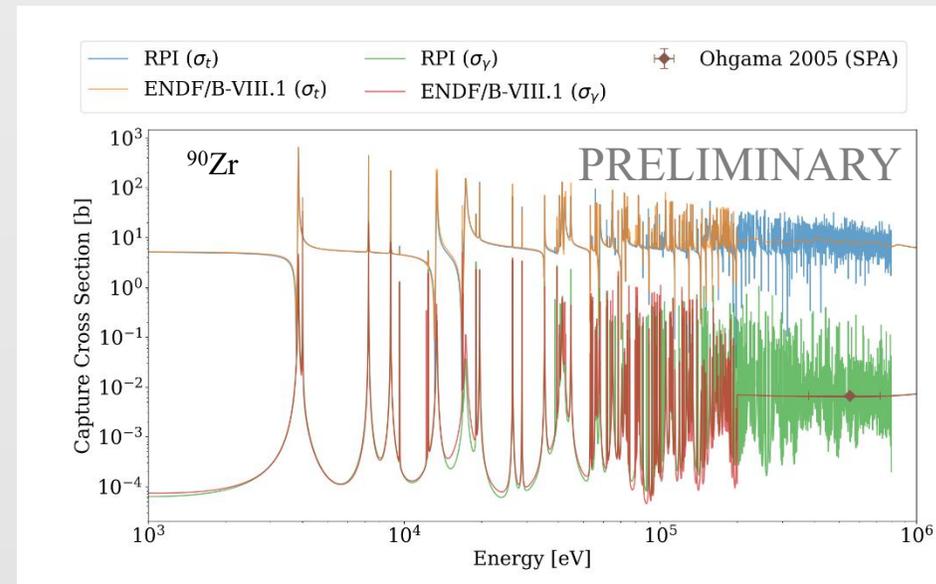
# Current Evaluation Progress and Next Steps

- $^{90,91}\text{Zr}$  resolved resonance region evaluations mostly complete using R-matrix theory in LRF-7 format
  - Resolved resonance regions of  $^{90,91}\text{Zr}$  extended from 200 keV to 800 keV, and 26 keV to 195 keV, respectively
  - Both evaluations require uncertainties/covariances and validation
- Preliminary optical model parameters determined for  $^{90,91,92,94}\text{Zr}$ 
  - Verification with shape elastic and ESAD data needed to finalize fitted OMPs
  - Adjustment of preequilibrium models of  $^{90,91}\text{Zr}$
- Final project/thesis deliverables are ENDF-6/GNDS  $^{90,91}\text{Zr}$  files to the NNDC

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