Zirconium evaluations

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for

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a passion for discovery

U.S. DEPARTMENT OF ENERGY | Office of Science

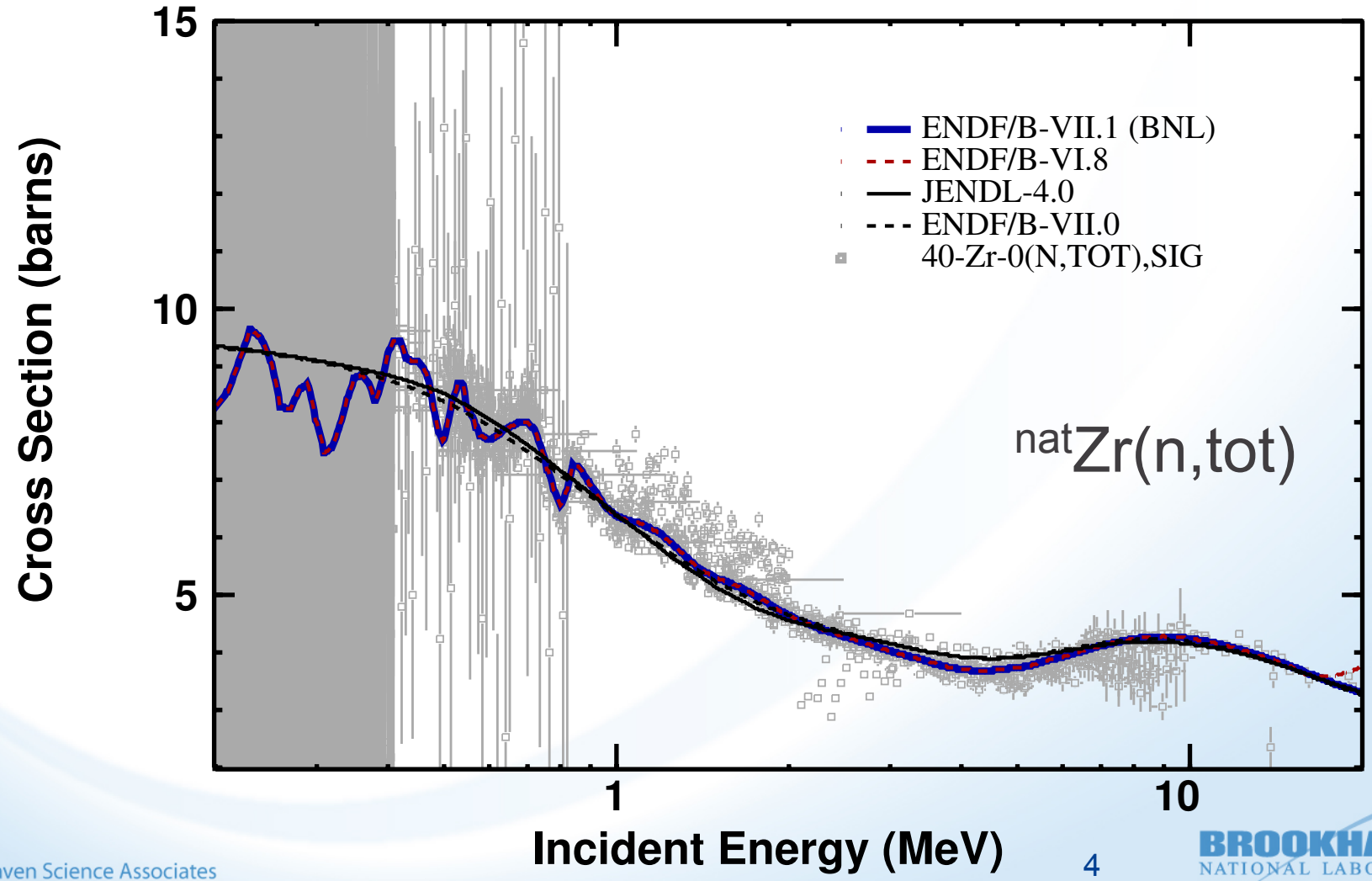
New Zr evaluations for ENDF/B-VII.1

- EMPIRE evaluation
- Leakage problems
- Resolution: fixed with JENDL-4
- Improved testing
- Next steps

About Zr and the evaluations

- Zr is a corrosion resistant material with low thermal neutron absorption cross section, so it is ideal in many reactor applications
- ^{90}Zr is magic so has low level density & lots of fluctuations
- 1970's ENDF/B-VI.8 evaluations
  - fits of cross sections
  - no gamma production, no double differential data
- 2000's ENDF/B-VII.0 evaluations
  - EMPIRE based
  - model based cross sections did not reproduce fluctuations
  - after release, learned performed poorly in TRIGA C132, C133 benchmarks

H.I. Kim, S. Mughabghab and R. Capote re-evaluated Zr isotopes with EMPIRE, fitting ENDF/B-VI.8 (n,tot)



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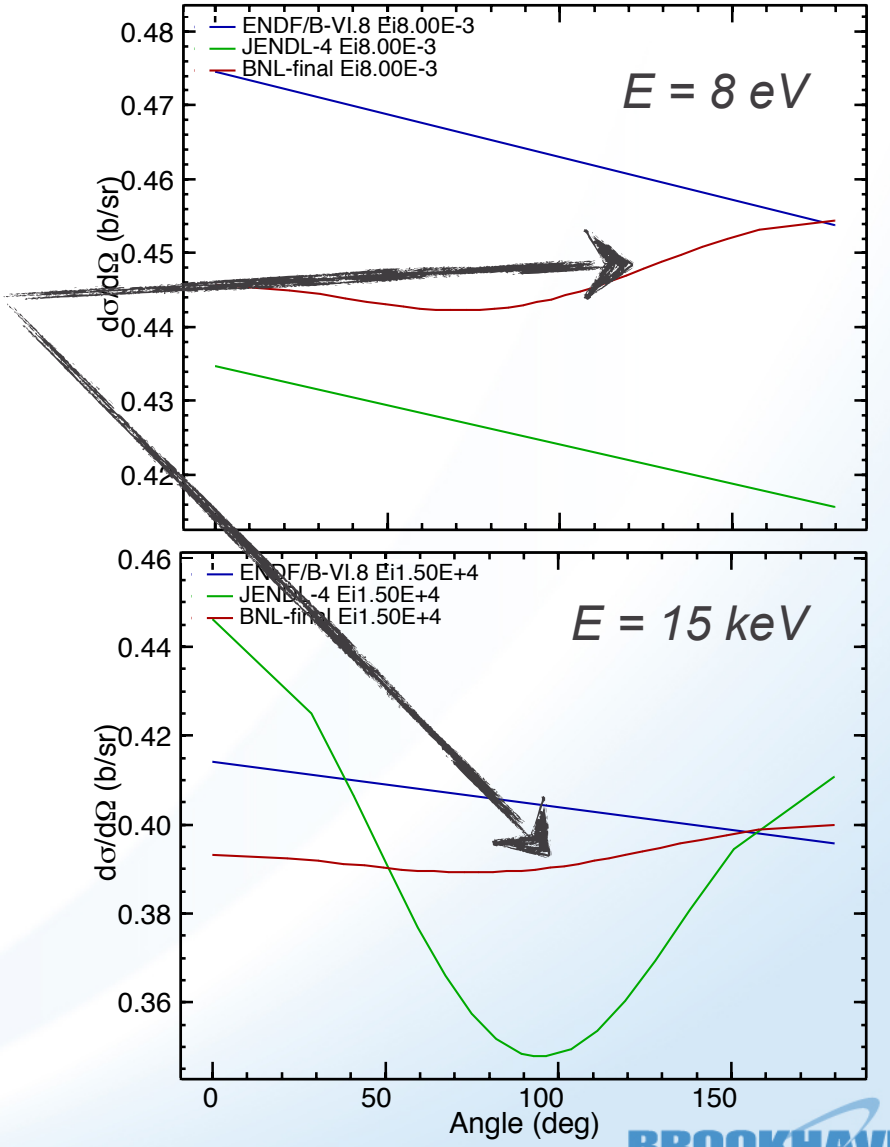
Strange (n,el) angular distributions changed leakage

Backward peaked at low energy?!?



Note: This keeps low energy neutrons from leaking out by scattering them back into the system, increasing k_{eff}

Reported by C. Lubitz, T. Trumbull

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Given the short time-scale before ENDF/B-VII.1 due, we looked to other libraries

- Since the double differential (n,el) cross section is

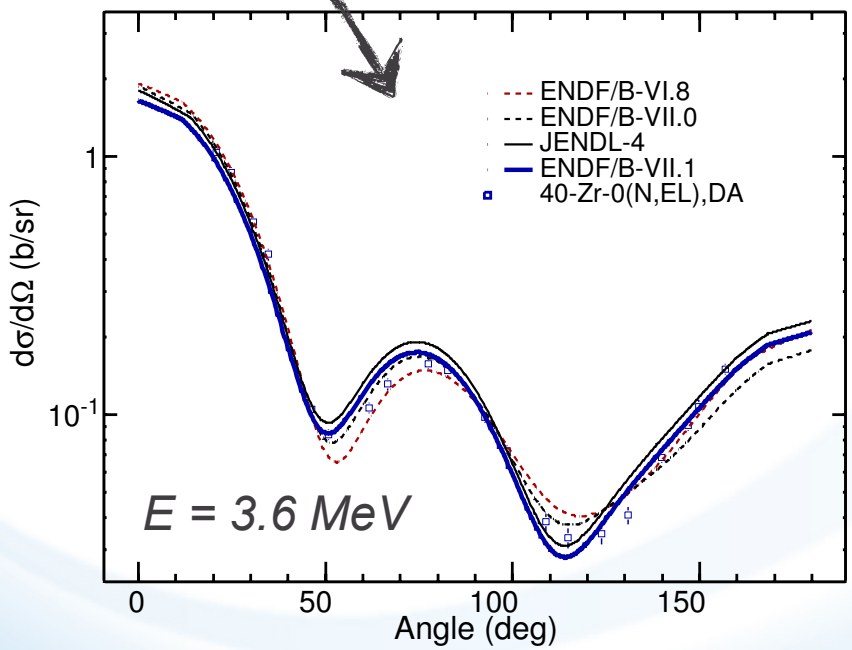
$$\frac{d\sigma(E)}{d\Omega} = (2\pi)^{-1}\sigma(E)P(E|\mu)$$

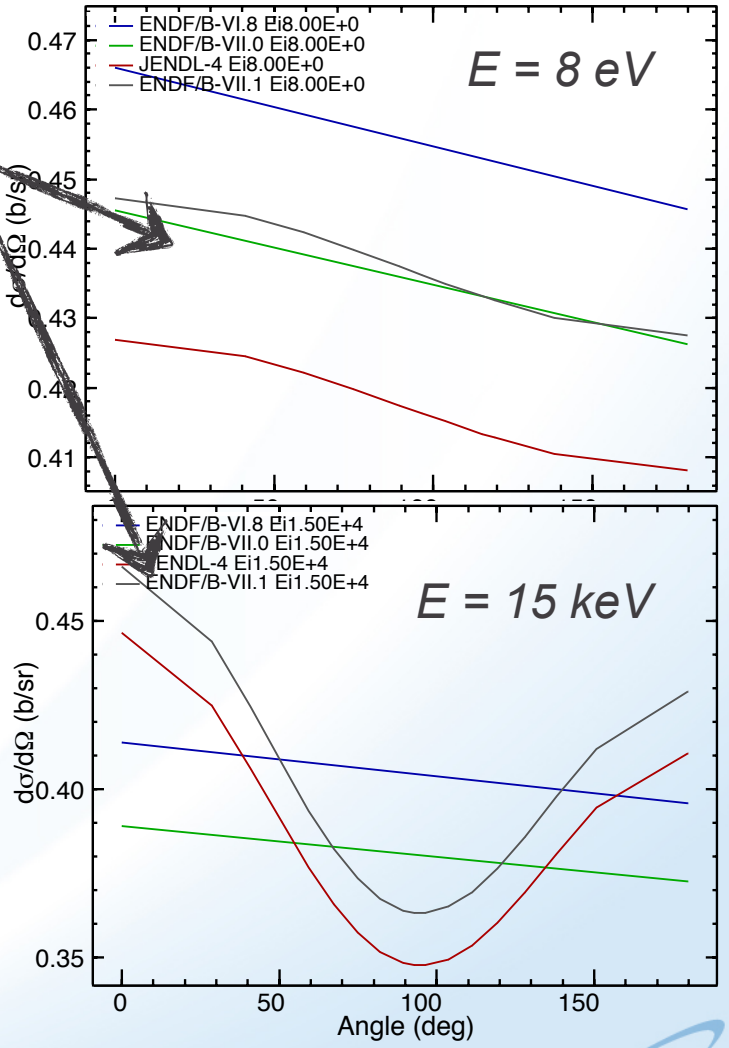
- We can preserve the excellent (n,el) total cross section by replacing only the $P(E|\mu)$ in file 4
- JENDL-4 used Koning-Deleroche OMP, a reasonable substitute given that we are at a closed shell
- FUDGE made this substitution simple

You call it a Franken-evaluation, we say that it is a strong case for organ donation

Agreement with data fantastic

Shape of distribution now makes sense





Said took this opportunity to start updating the resonances

- ^{90}Zr all new
- ^{91}Zr first pass at fixes

	^{90}Zr		^{91}Zr	
Reaction	σ_T **(barn)**	I_γ **(barn)**	σ_T **(barn)**	I_γ **(barn)**
Total	5.50762	-	11.0729	-
Elastic	5.49765	-	9.85728	-
Capture	9.97256×10^{-3}	0.132506	1.21566	6.0062

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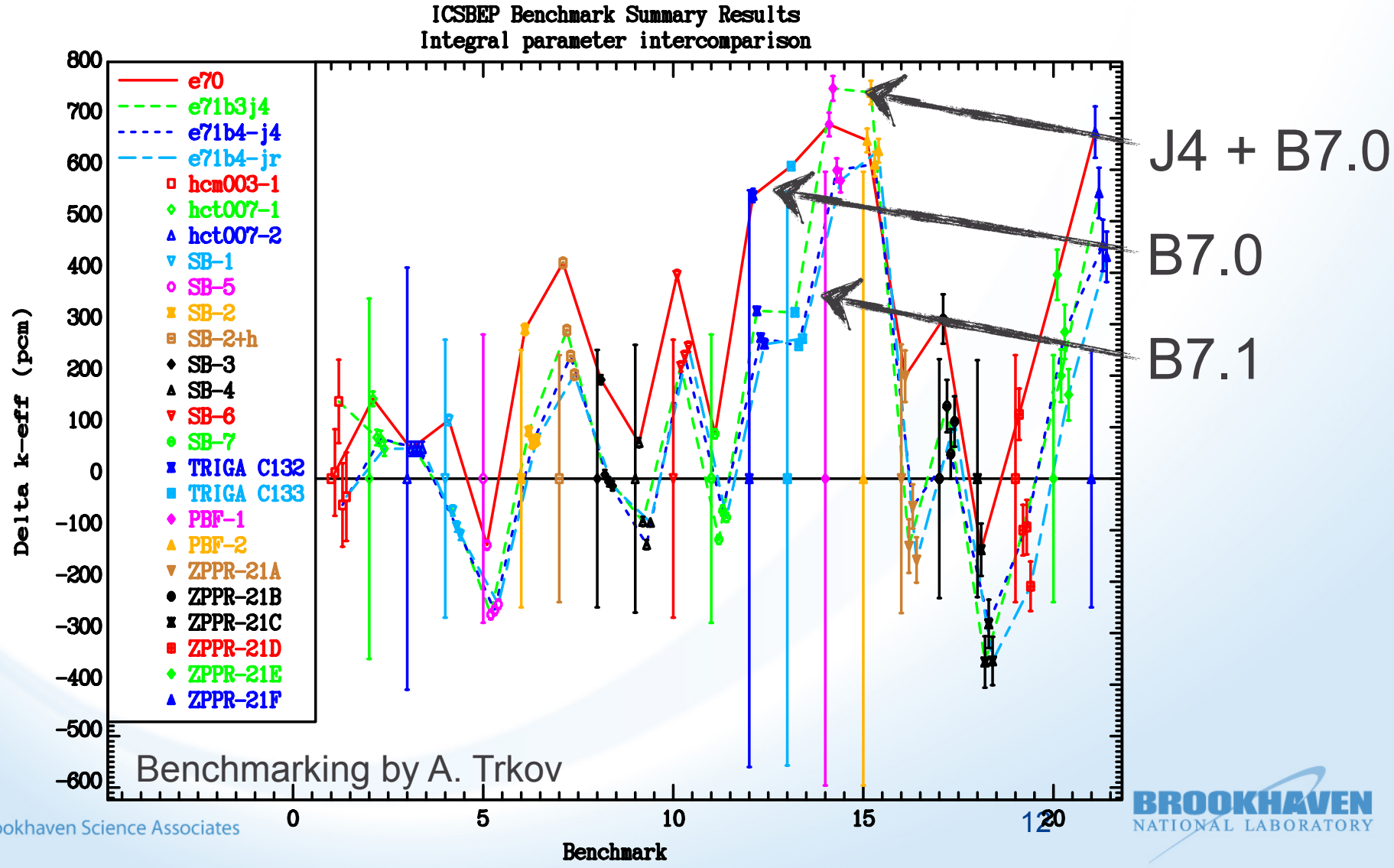
Benchmarking of new evaluations



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Next steps

- Said to finish redoing all resonances
  - ^{91}Zr to get major RRR upgrade: fit most of fluctuations with extended RRR instead of tuned EMPIRE calc.
  - $^{92\text{-}94}$Zr could use updates
  - ^{95}Zr crap (URR only)
- Redo EMPIRE calculations with new soft-rotor OMP
- Make sure distributions are well behaved