

# Integral Validation of TENDL-2014 with EASY-II

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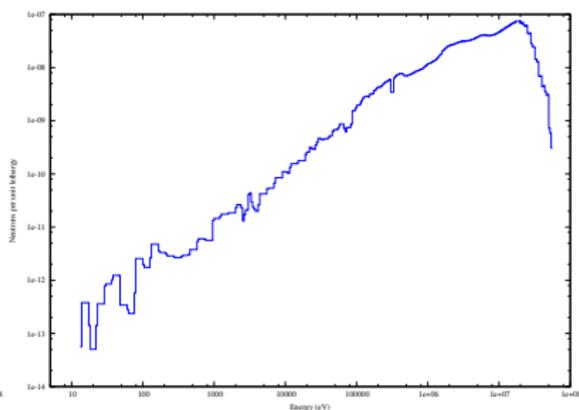
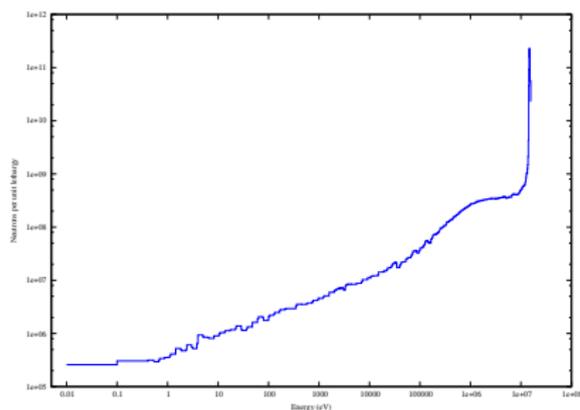
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Integral experimental values taken from multiple facilities with various beams, targets, sample sizes, measurement apparatus, *data post-processing*, etc

- ▶ JAEA FNS [D-T]
- ▶ ENEA FNG [D-T]
- ▶ FZK [D-Be, D-Li]
- ▶ TUD & SNEG [D-T]
- ▶ NPI Řež [p-D]
- ▶ Jülich/Qaim [D-Be]
- ▶  $^{252}\text{Cf}$  [sF]

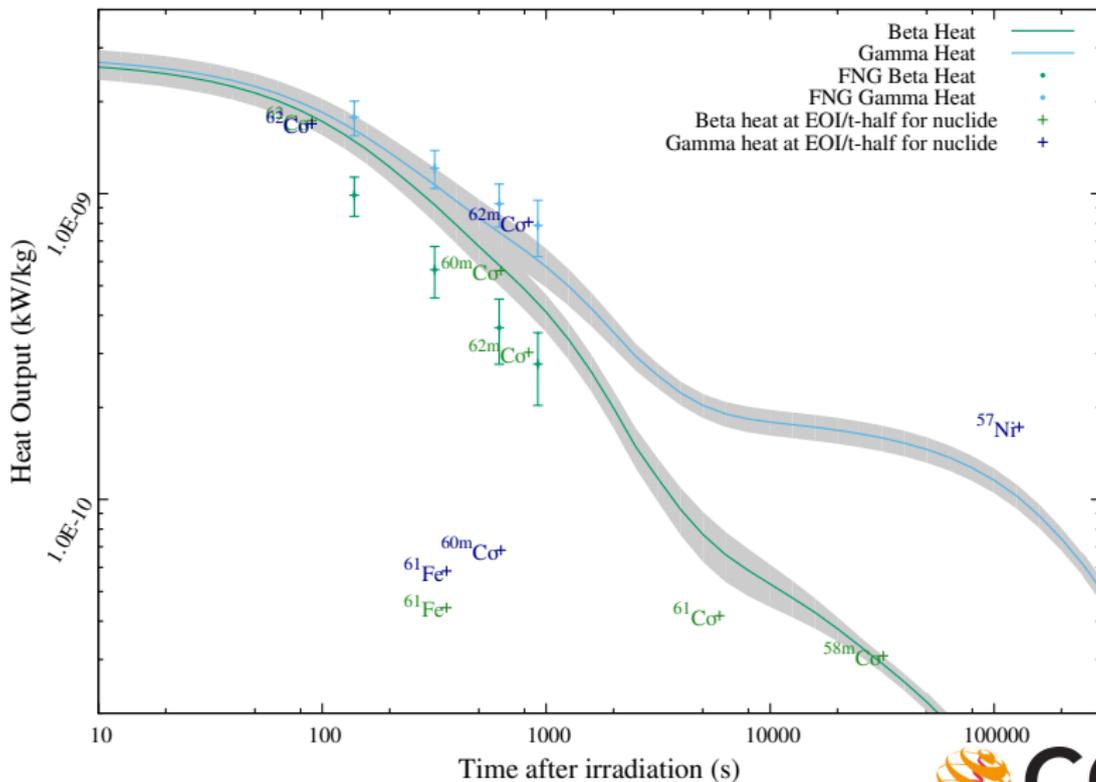


Flux spectra, methods of characterisation and energy discretisation vary over experiments. One (often non-negligibly populated!) bin  $1E-5$  to  $1E-1$  with Vitamin-J 175 not useful for non-threshold



FNS 5-minute position 3 (left) and FZK SS316 d-Li (right)

- ▶ Different responses measured by different groups:  $\gamma$ -spec, total spec, total heat...
- ▶ Spec. can yield product nuclide inventory  $\rightarrow$  RR/XS
  - ▶ These are *mostly* insensitive to nuclear data
- ▶ If product nuclides are not identified in measurement (eg total heat), they must be inferred by analyst and *depend greatly on nuclear data XS and DD!*
  - ▶ New and complete analysis required for each library set, eg FNS decay heat reports such as CCFE-R(15)25 (data included in integral validation report)
  - ▶ New analysis of FNS and FNG heat measurements completed for this work

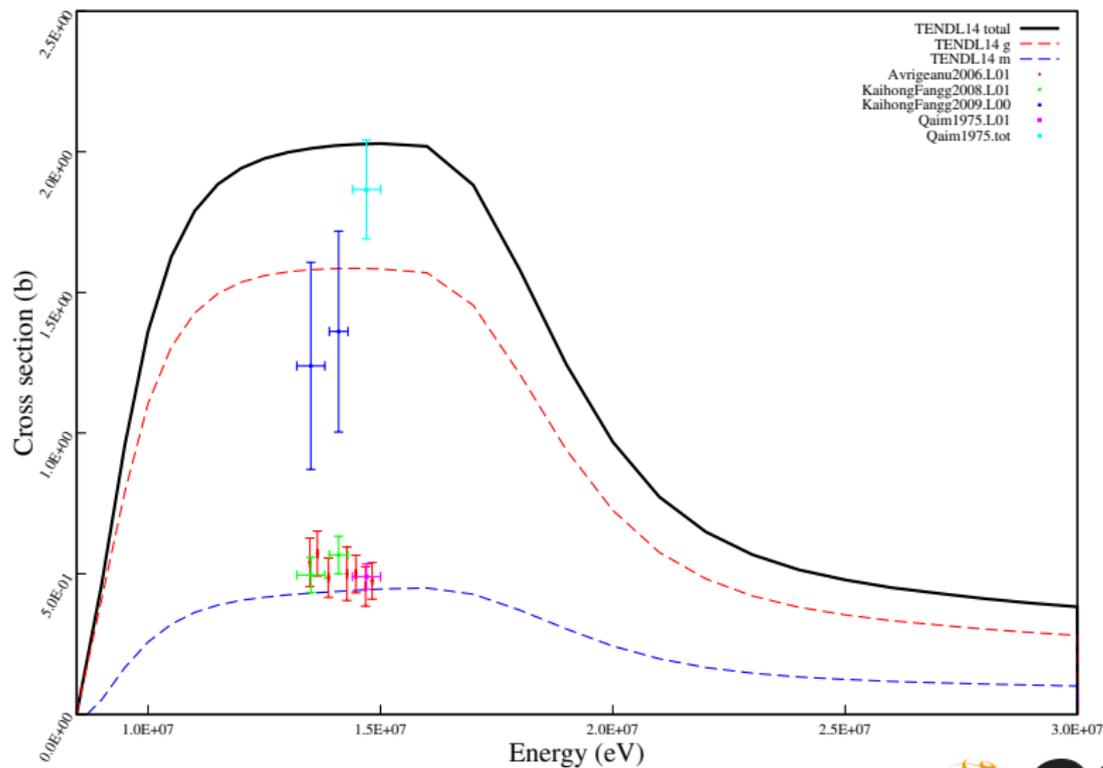


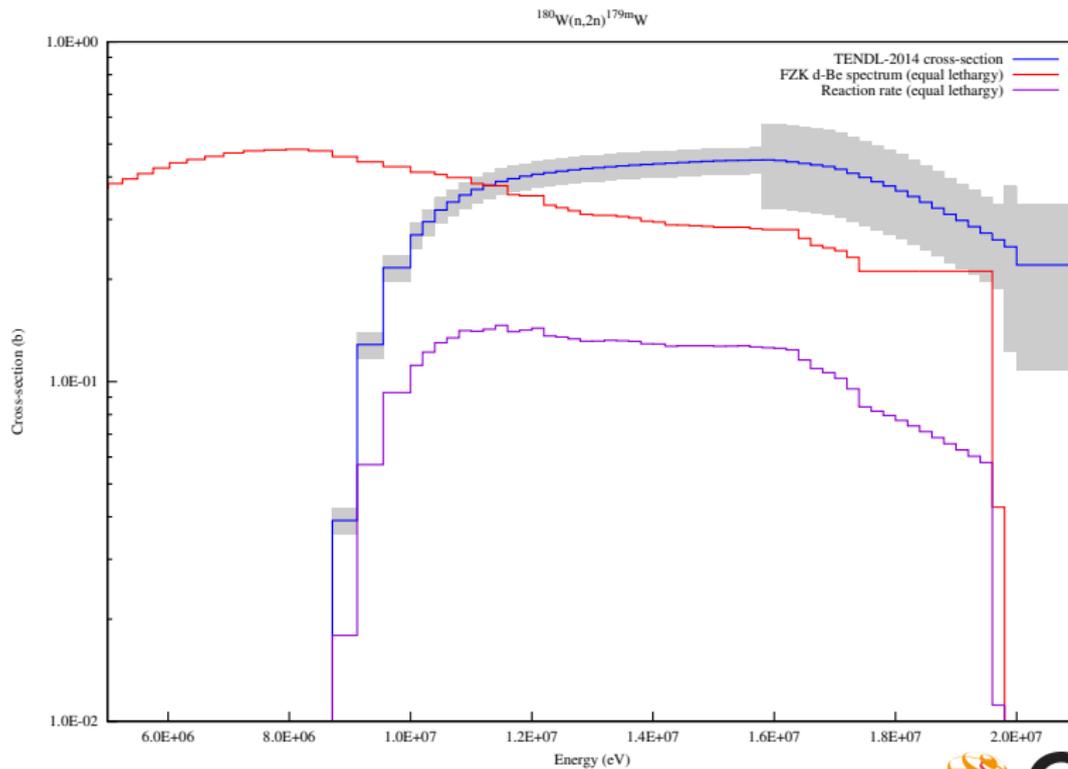
- ▶ Technological approach to reaction (and isomer) identification generally eliminates errors of omission - *however*:
  - ▶ Some isomer production reactions are absent  $^{179}\text{Hf}(n,n')^{179m}\text{Hf}$
  - ▶ Some machine error has resulted in spurious branching ratios for  $^{115}\text{In}(n,\gamma)$  and  $^{92}\text{Mo}(n,p)$
- ▶ > 30MeV reactions given by MT=5 with yield MF=10 file
  - ▶ While EAF reports claim reaction identification, TENDL leaves this implicitly ambiguous. Reactions which are unique were identified, others could not be validated.
- ▶ Pathway allocation and identification of reactions is a subtle problem for validation.

Product	Pathway(s)	%
Ta182	W182(n,p)	49.4
	W182(n,p)Ta182m(IT)	41.3
	W182(n,p)Ta182n(IT)	3.7
	W183(n,d)	1.8
In117	Sn117(n,p)	87.9
	Sn118(n,np)	6.9
	Sn118(n,d)	3.1
	Sn117(n,p)In117m(IT)	1.5
	Sn120(n, $\alpha$ )Cd117m( $\beta^-$ )	1.5
Sc47	Ti47(n,p)	41.2
	Ti48(n,np)	25.9
	Ti48(n,d)	18.1
	V50(n, $\alpha$ )	9.7
	V51(n,n $\alpha$ )	5.4

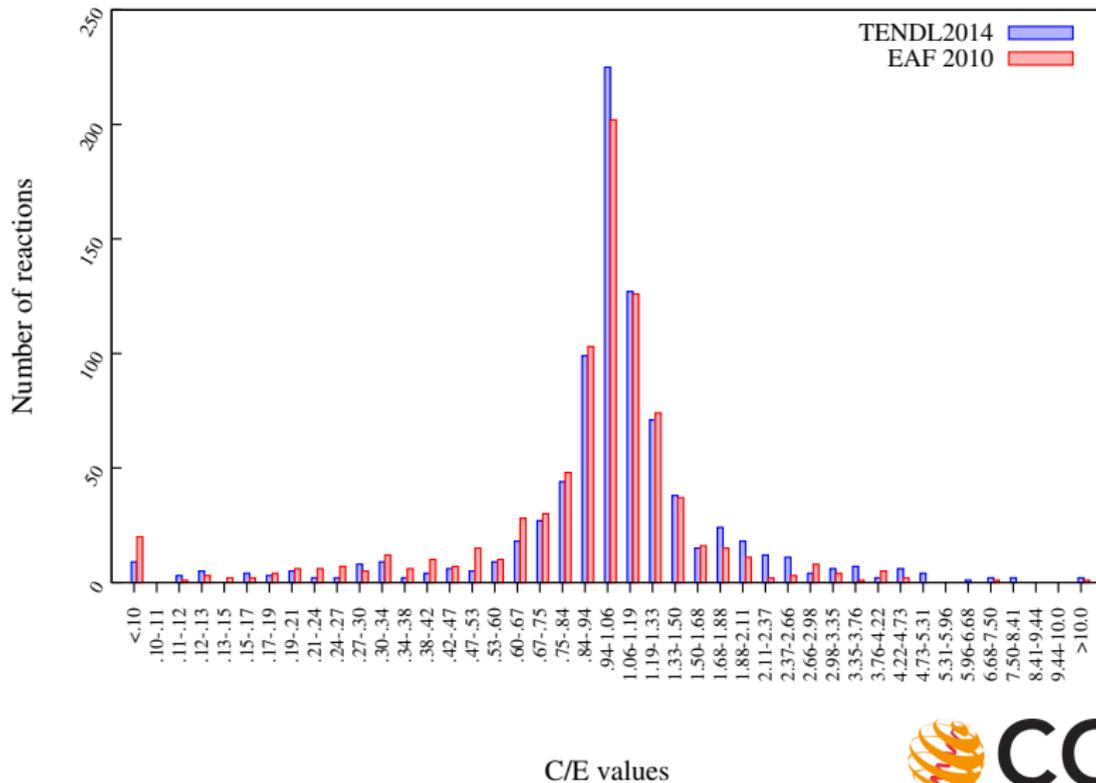
- ▶ Ta182 used for W182(n,p) validation
- ▶ In117 reactions have been measured so (n,p) used
- ▶ Sc47 reactions poorly known and various path uncert. leaves (n,p) too fragile

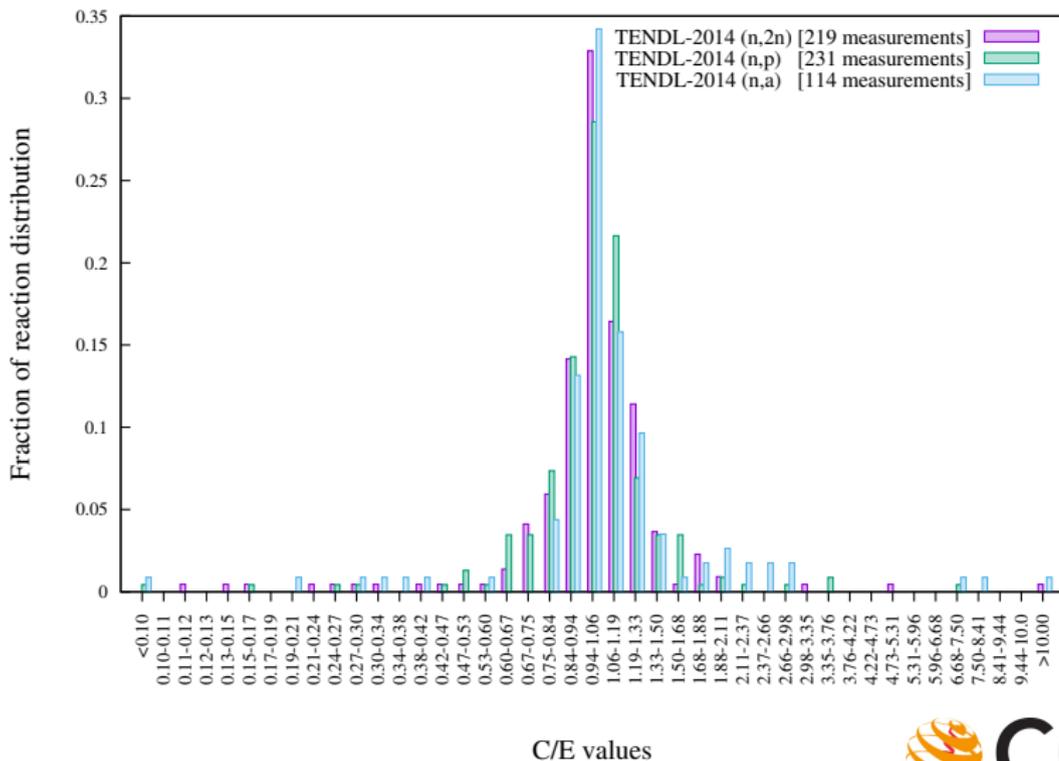
- ▶ Validation performed by:
  - ▶ Comparing collapsed cross-sections with those determined by experiment
  - ▶ Visual inspection of EXFOR against differential data
  - ▶ Pathway analysis performed for all experiments to verify that production of measured nuclide due to specified reaction
- ▶ Combination of validation for reactions with measurements and technological nature of library generation supports whole library **by its construction methodology**
- ▶ Consider an example,  $^{180}\text{W}(n,p)$ :





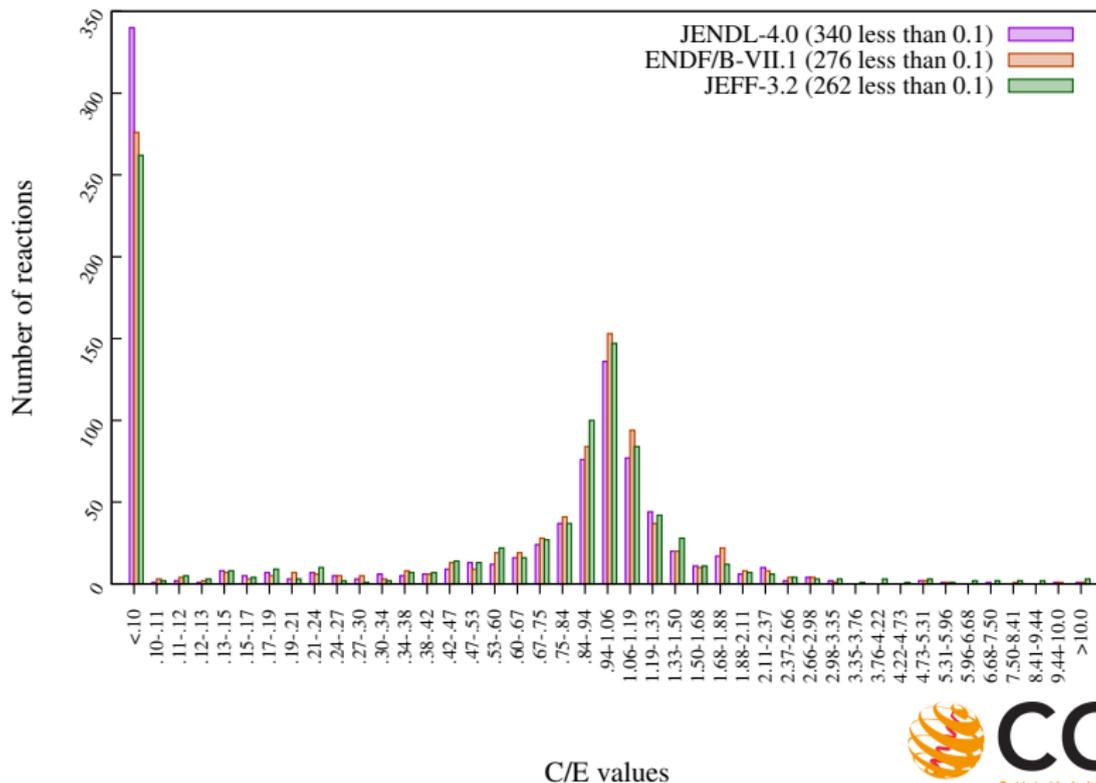
841 measurements were considered with  $\sigma_C/\sigma_E$  distribution:





- ▶ 66000+ neutron induced reactions with 5000+ 'important' reactions < 2000 with any experimental data and only a few hundred with integral
- ▶ Libraries built with hand-modification **cannot** use the tuned subset to support those without measurements
- ▶ Impossibility of measuring total set makes validation capabilities of TENDL (or another similarly constructed) absolutely unique
- ▶ Relying upon legacy approach by addition of reactions presents some problems:

# JEFF/ENDF/JENDL missing many reactions *with integral data*:



# Future work

- ▶ Non-threshold validation based upon 'compilation of compilations' from Kopecky, Mughabghab, KADoNiS, Rochman including:
  - ▶ Thermal/maxwellian cross sections
  - ▶ Integral resonances
  - ▶ Astrophysical MACS
- ▶ For the next integro-differential report:
  - ▶ More data from quality, peer-reviewed sources
  - ▶ Involvement of others?

## Some thoughts:

- ▶ TENDL-2014 outperforms EAF-2010, which was modified with full knowledge of the integral values
- ▶ Validation of TENDL extends beyond experimental subset due to methodology, unlike any other library
- ▶ FISPACT-II allows versatile simulation which can probe DH subtleties, take advantage of full TENDL data and provide more robust calculations of nuclear observables

<http://www.ccfе.ac.uk/EASY.aspx>

**Thank you for your attention**