Integral Validation of TENDL-2014 with EASY-II

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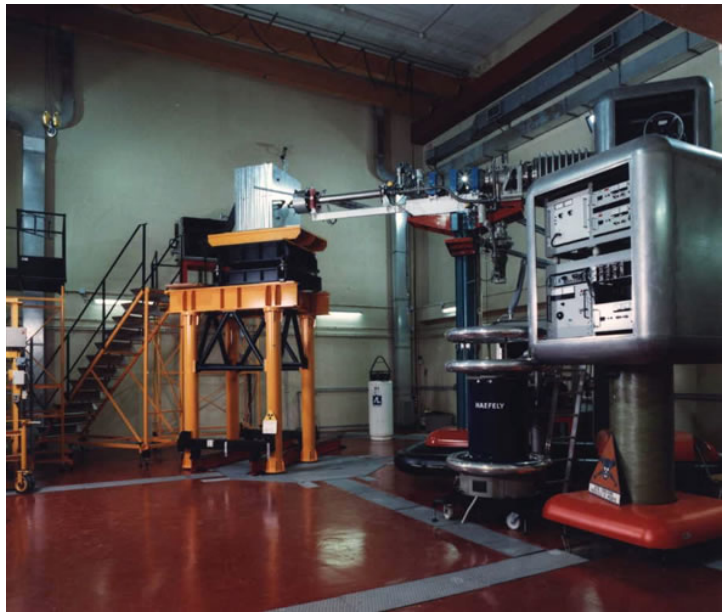
29 April 2015

Contents

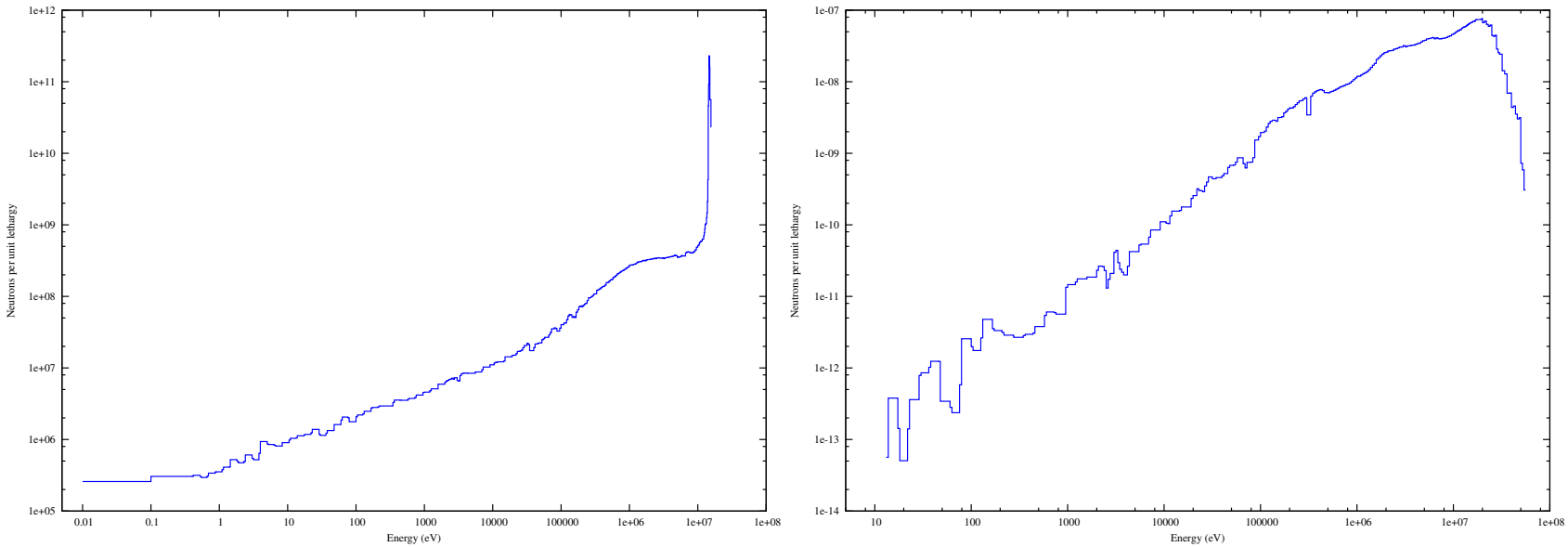
This work was funded by the Research Councils United Kingdom Energy Programme under grant EP/I501045

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}Cf [sF]

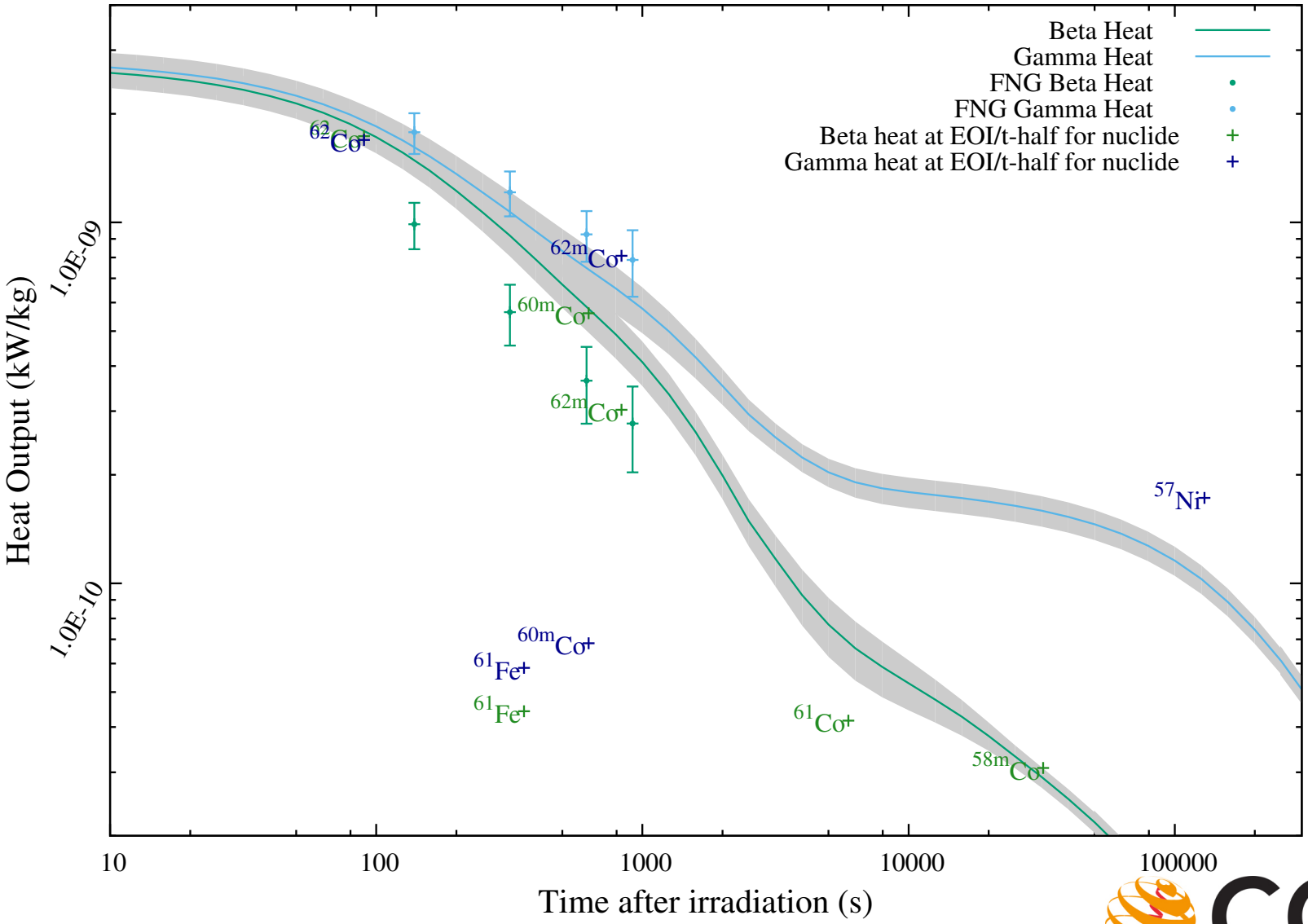


Flux spectra, methods of characterisation and energy discretisation vary over experiments. One (often non-negligibly populated!) bin 1E-5 to 1E-1 with Vitamin-J 175 not useful for non-threshold



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

- Different responses measured by different groups: γ-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



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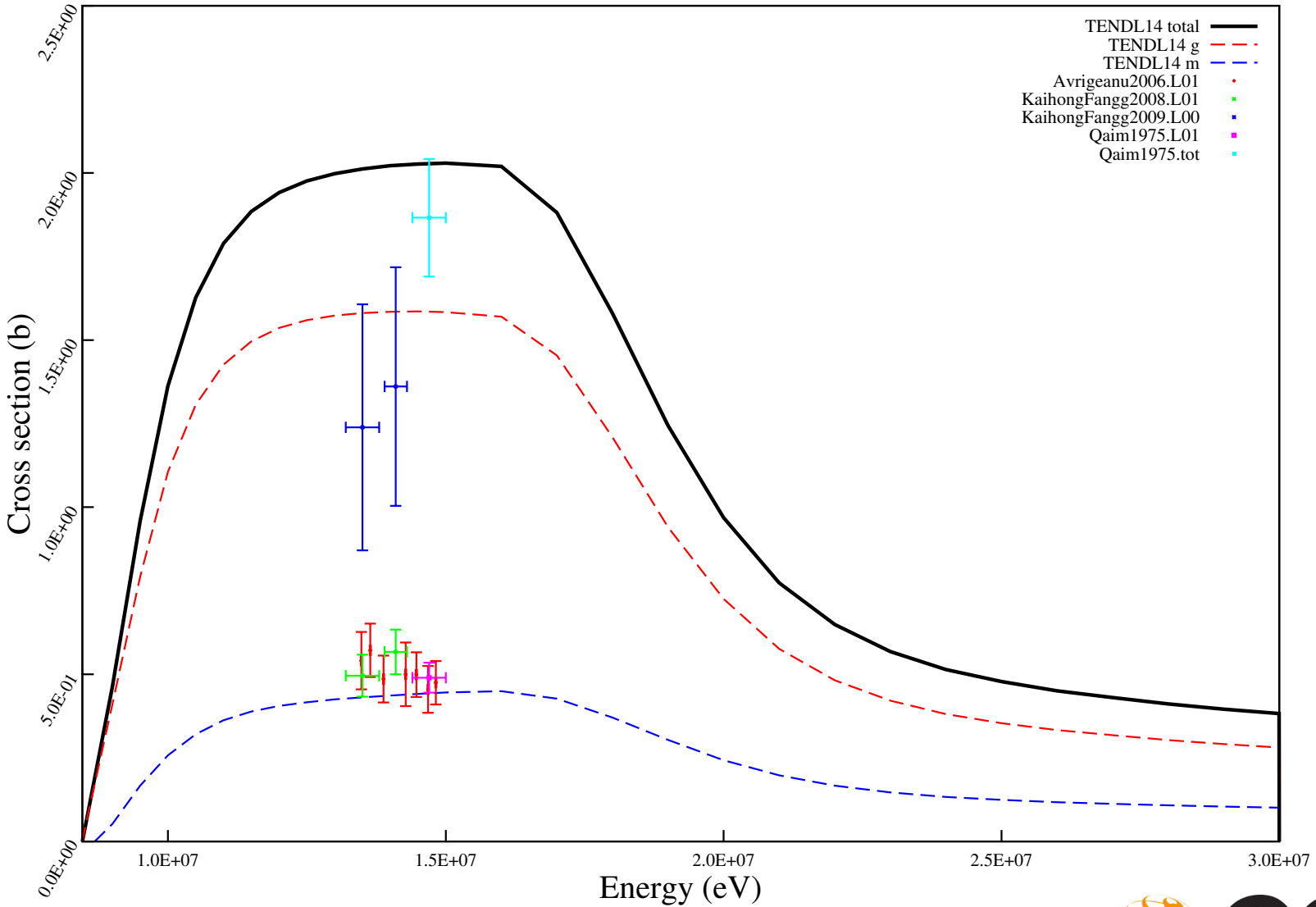
- Technological approach to reaction (and isomer) identification generally eliminates errors of omission - *however*:
  - Some isomer production reactions are absent ^{179}Hf(n,n')^{179n}Hf
  - Some machine error has resulted in spurious branching ratios for ^{115}In(n,γ) and ^{92}Mo(n,p)
- $>$ 30MeV 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,α)Cd117m(β-)	1.5
Sc47	Ti47(n,p)	41.2
	Ti48(n,np)	25.9
	Ti48(n,d)	18.1
	V50(n,α)	9.7
	V51(n,nα)	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}W(n,p):



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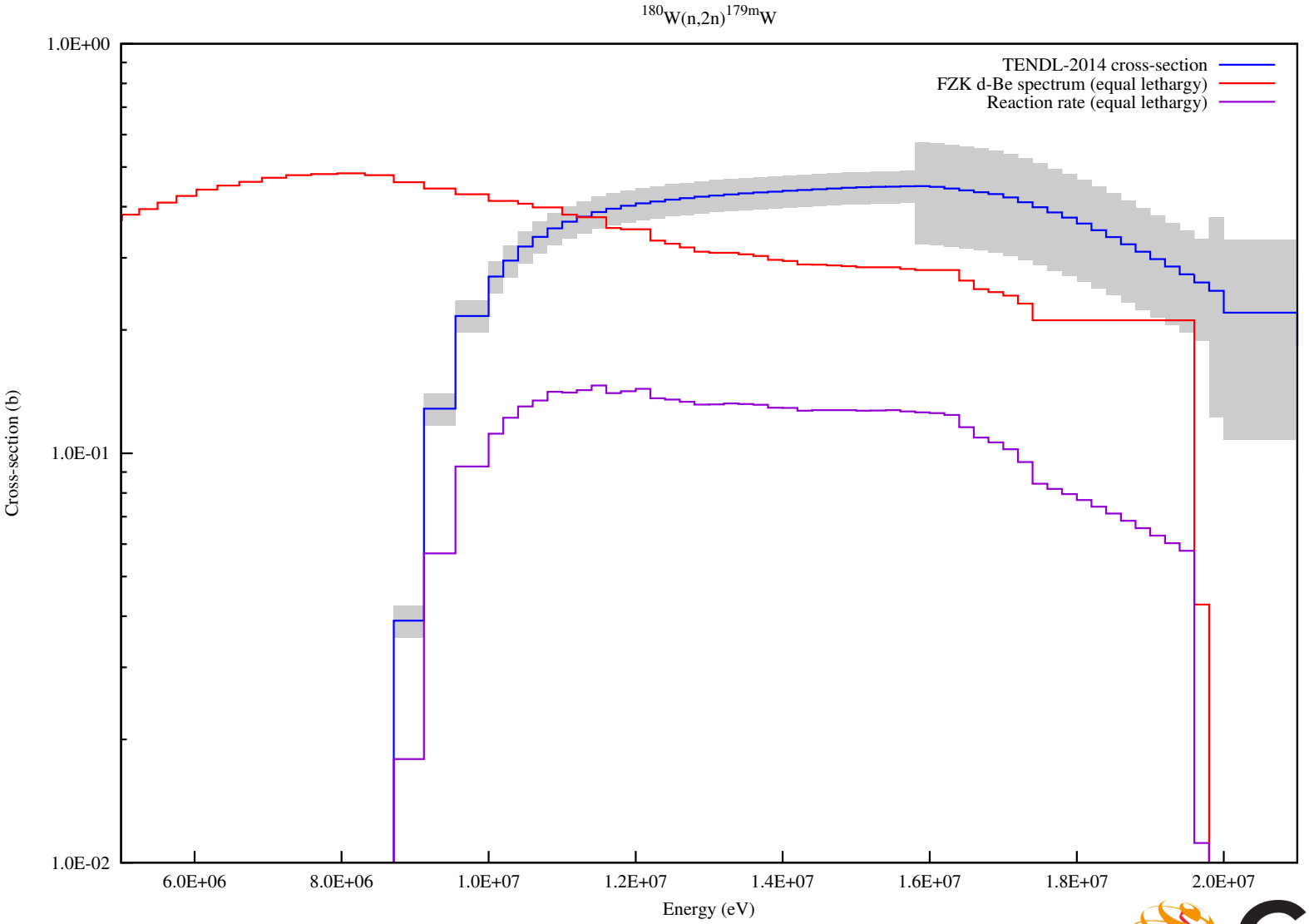

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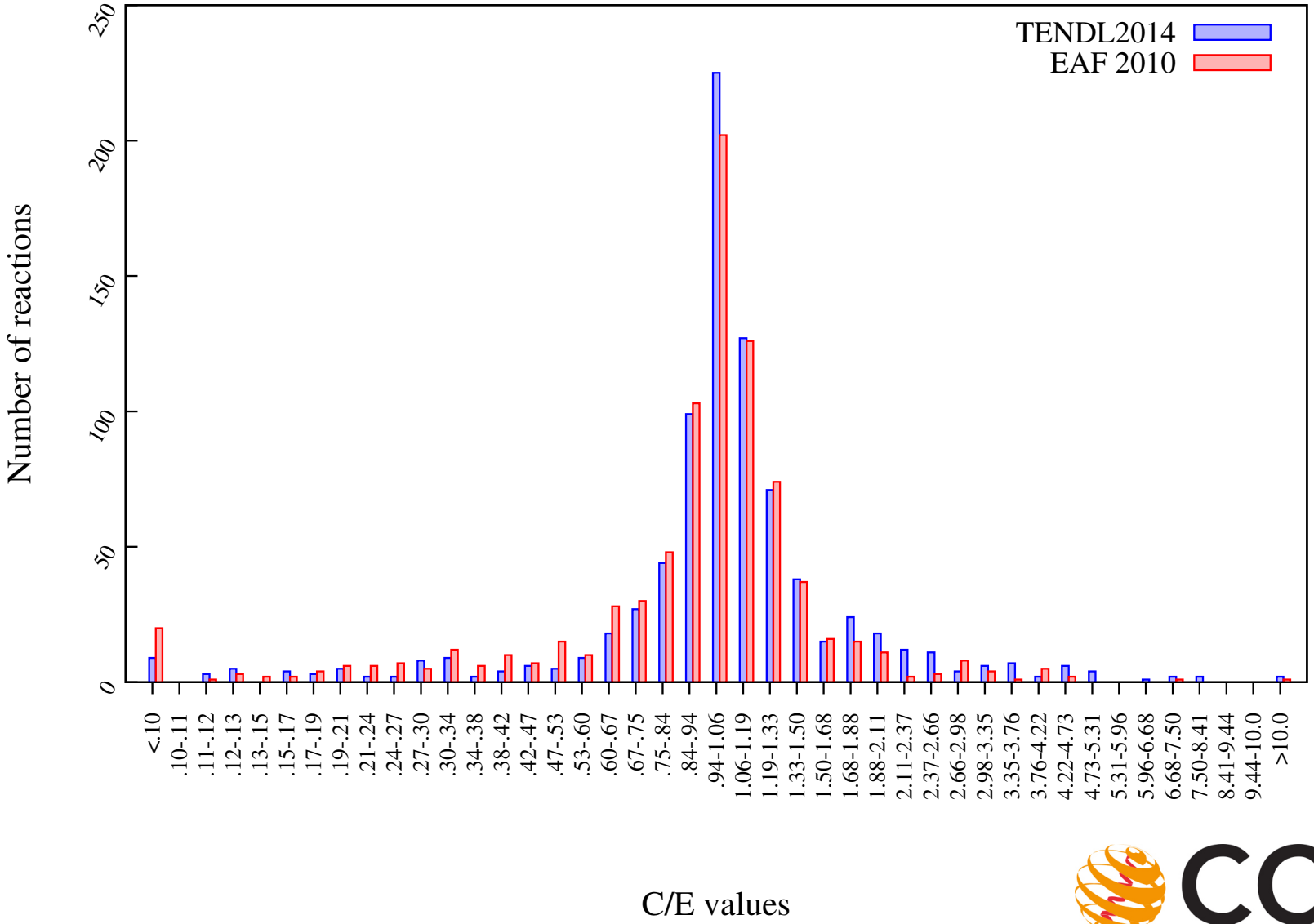
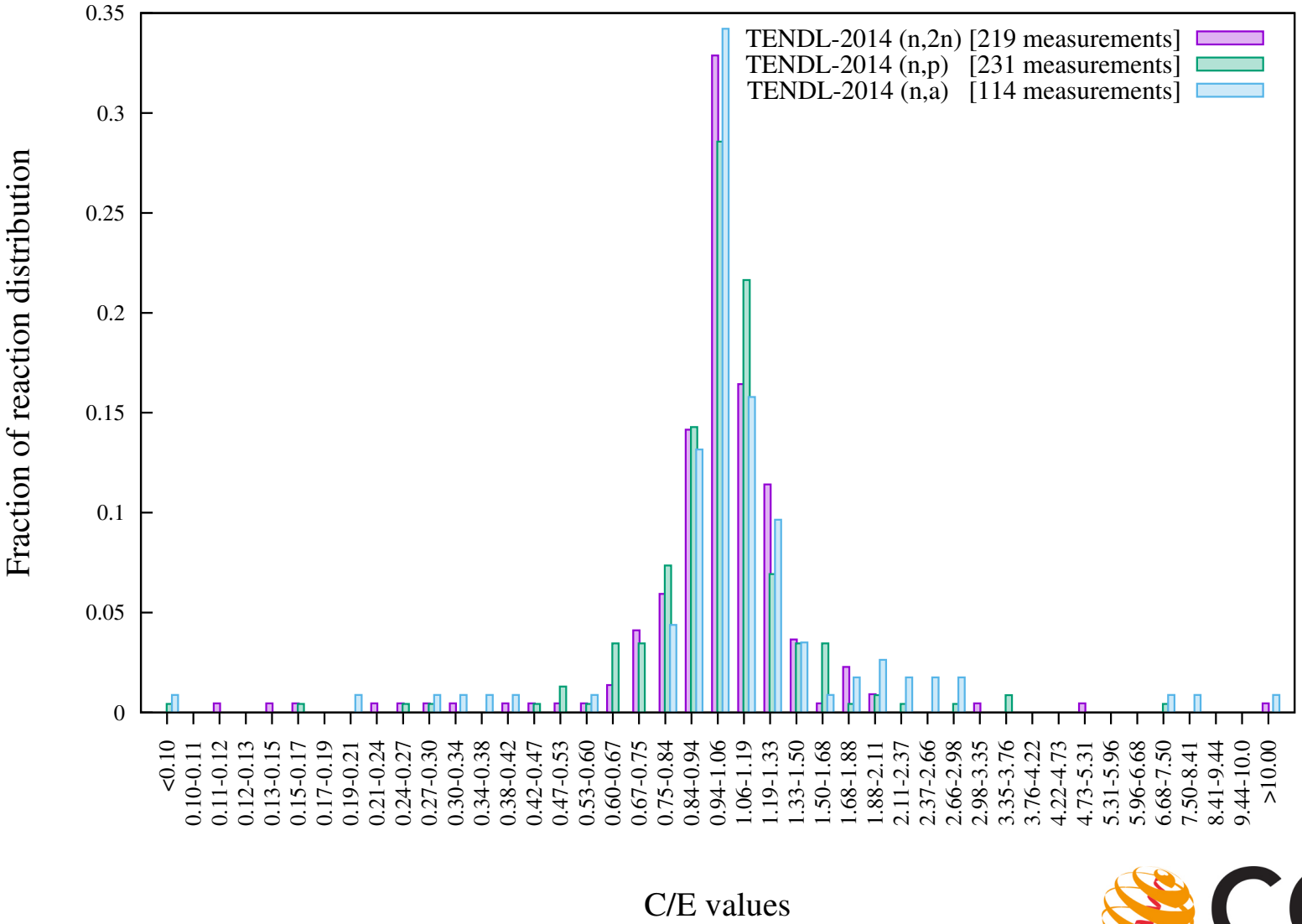
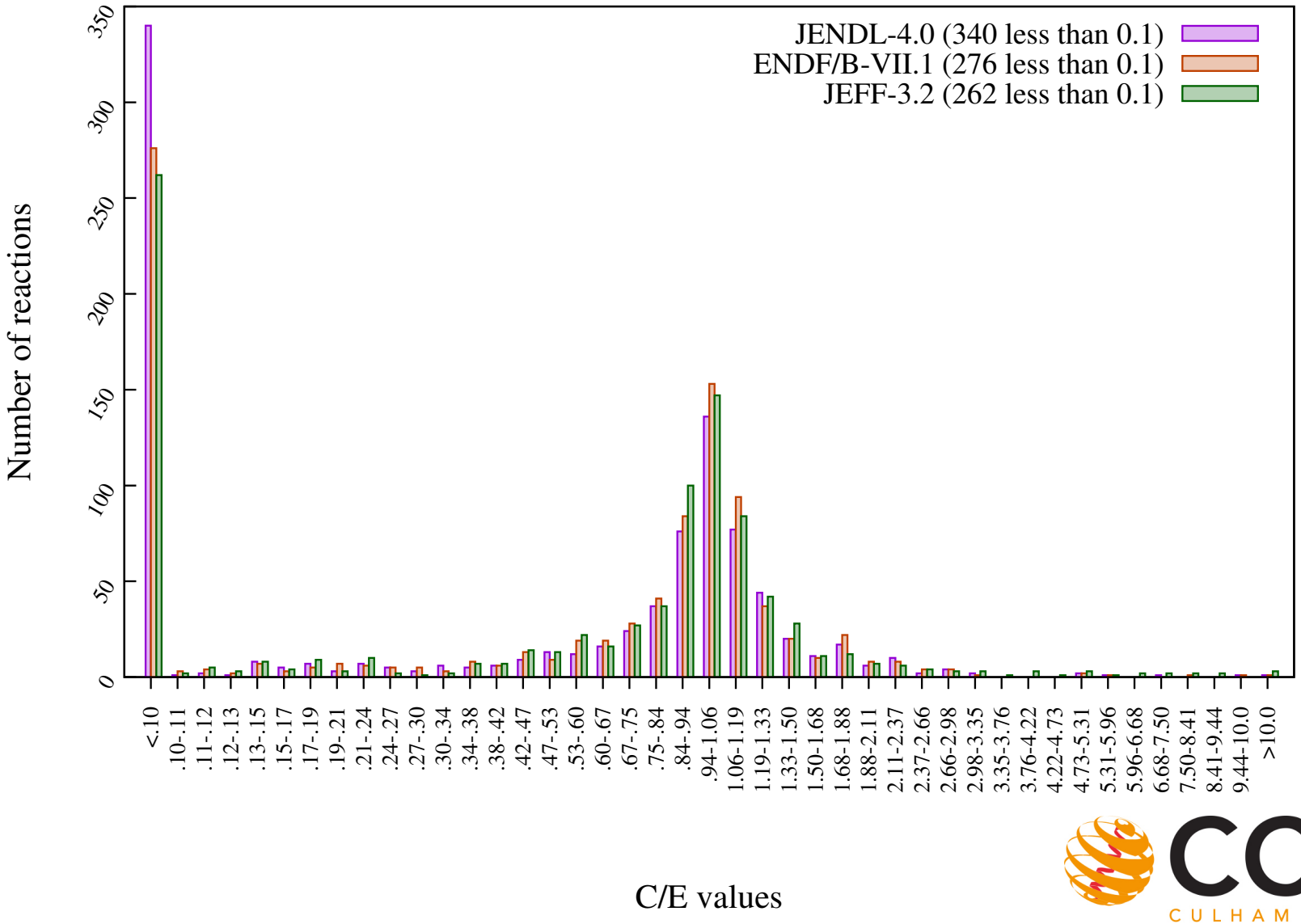
841 measurements were considered with σ_C/σ_E distribution:




TENDL-2014 (n,2n) [219 measurements]
TENDL-2014 (n,p) [231 measurements]
TENDL-2014 (n,a) [114 measurements]
Fraction of reaction distribution
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
<0.10
0.10-0.11
0.11-0.12
0.12-0.13
0.13-0.15
0.15-0.17
0.17-0.19
0.19-0.21
0.21-0.24
0.24-0.27
0.27-0.30
0.30-0.34
0.34-0.38
0.38-0.42
0.42-0.47
0.47-0.53
0.53-0.60
0.60-0.67
0.67-0.75
0.75-0.84
0.84-0.94
0.94-1.06
1.06-1.19
1.19-1.33
1.33-1.50
1.50-1.68
1.68-1.88
1.88-2.11
2.11-2.37
2.37-2.66
2.66-2.98
2.98-3.35
3.35-3.76
3.76-4.22
4.22-4.73
4.73-5.31
5.31-5.96
5.96-6.68
6.68-7.50
7.50-8.41
8.41-9.44
9.44-10.0
>10.00
C/E values

- 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.ccfe.ac.uk/EASY.aspx

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Thank you for your attention