Review of the Most Reactor Relevant Cumulated Fission Product Yields

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Purpose of this document

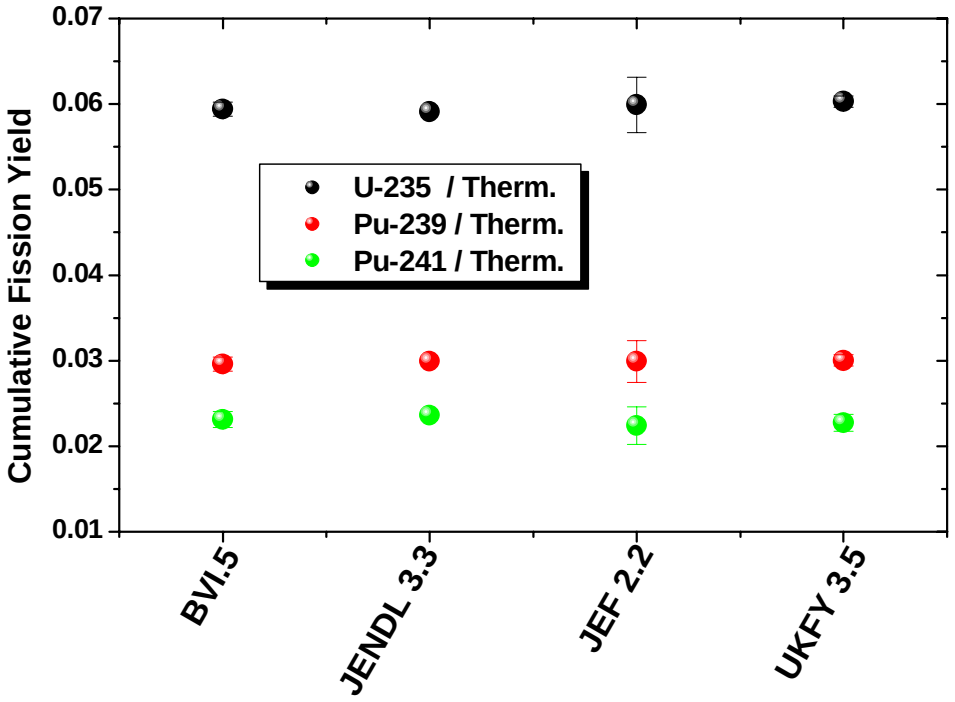
- Overview of the cumulative yields for various Fission Products which are important for reactor and fuel cycle applications:
  - Most absorbing FP burnup credit
  - Long Lived FP,
  - Burnup indicator,
  - Fission rate normalization
  - …

Only the following reactions $^{235}U(n_{th},f)$, $^{239}Pu(n_{th},f)$, $^{241}Pu(n_{th},f)$ were considered.

- The B6.5, JENDL3.3, JEF2.2 and UKFY3.5 libraries are compared.
- Some integral trends are reminded and checked against UKFY3.5

Working document for possible improvements of the UKFY3.6 Cumulative Fission Yields

38- Sr- 92



Interest: Gamma peak-check experiment (Fission rate normalization)

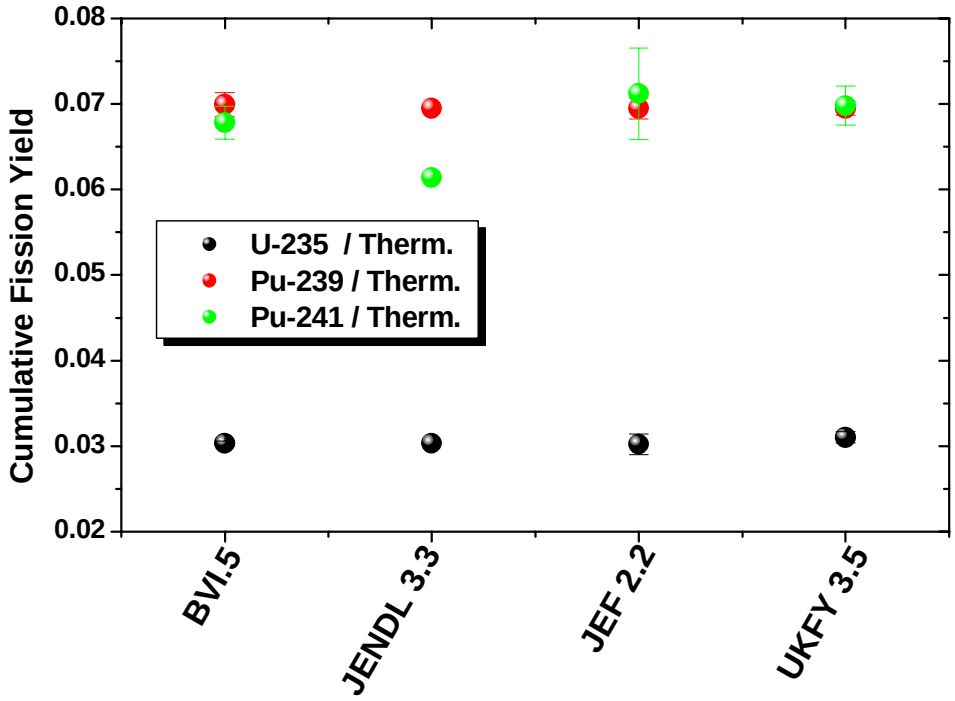
Comments:

• No clear integral trend. Nevertheless, the JEF2.2 values seem to be satisfactory.

• The too large uncertainties which were observed in UKFY3.4 have been corrected in UKFY3.5

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.0594	8.31E-4	0.0296	8.3E-4	0.0231	9.22E-4
JENDL3.3	0.0591	0	0.0299	0	0.0236	0
JEF2.2	0.0599	0.00325	0.0299	0.00246	0.0224	0.00218
UKFY3.5	0.0603	6.6E-4	0.03	6.6E-4	0.0227	9.89E-4

45- Rh- 103



Interest: Important absorbing FP (Burnup credit)

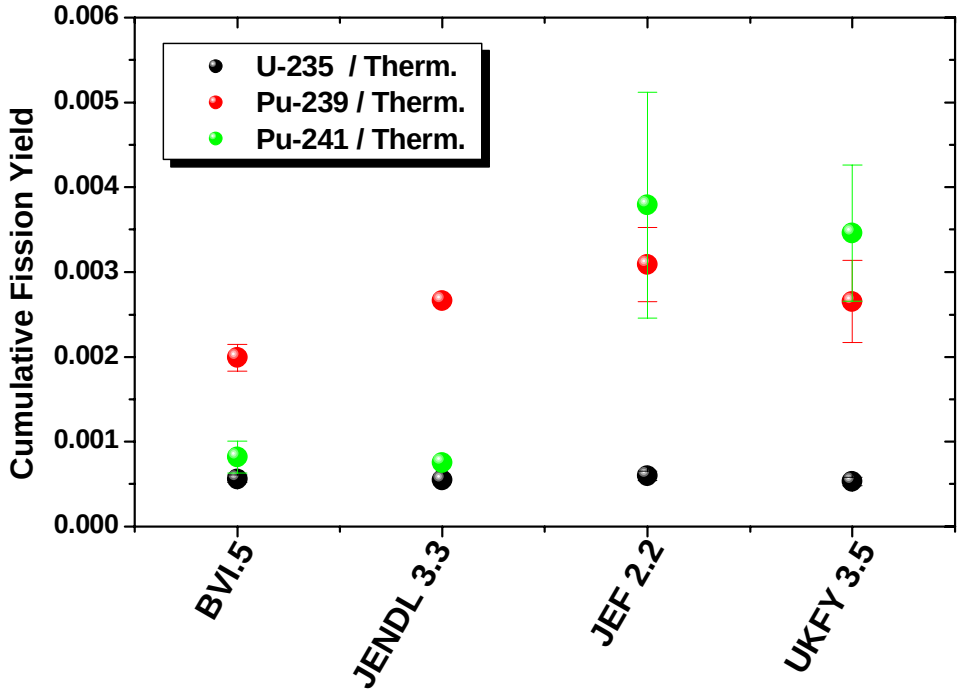
Integral trend [1,5]: The cumulative yields look slightly overestimated in JEF2.2

Comments on UKFY3.5 file:

- The increase (compared to JEF2.2) for U235 is not in agreement with P.I. Experiment
- The slight decrease (compared to JEF2.2) for Pu241 is in agreement with the integral trend
- Uncertainties have been reduced in UKFY3.5

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.0303	3.03E-4	0.0699	0.0014	0.0678	0.0019
JENDL3.3	0.0303	0	0.0695	0	0.0614	0
JEF2.2	0.0302	0.00123	0.0695	0.00126	0.0712	0.00535
UKFY3.5	0.031	6.83E-4	0.0695	8.34E-4	0.0698	0.0023

50- Sn- 126



Interest: Long Lived Fission Product

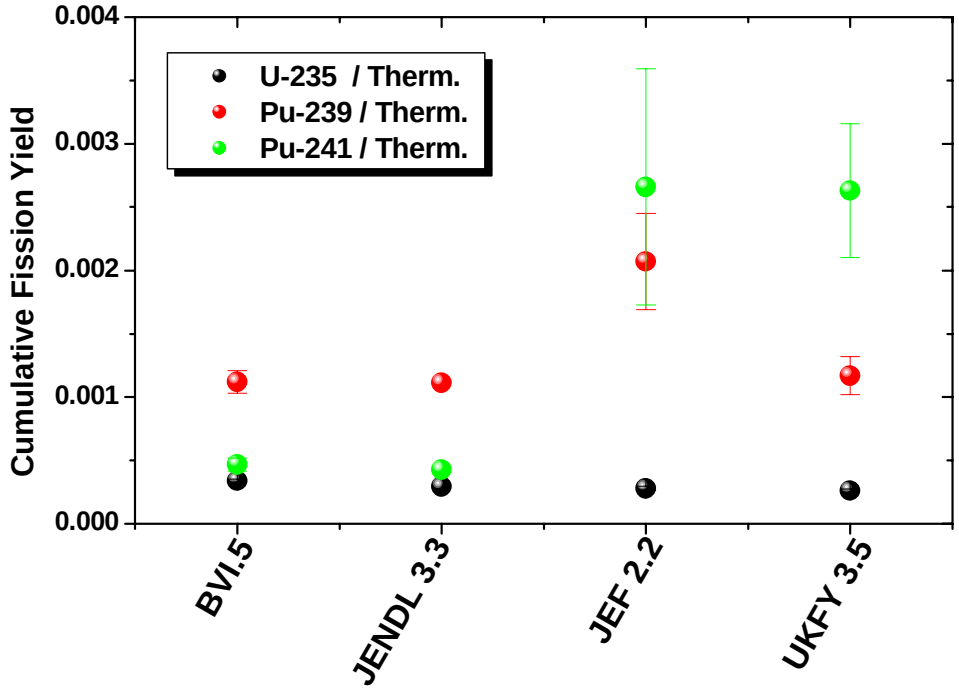
Integral trend [3]: Strong overestimation for the Pu-isotopes in JEF2.2

Comments:

- For all reactions, a decrease of the UKFY3.5- values (compared to JEF2.2) can be observed, which is in agreement with the integral trends
- Note that a strong disagreement exists between B6.5 and UKFY3.5 values for Pu241

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	5.61E-4	4.49E-5	0.00199	1.59E-4	8.2E-4	1.89E-4
JENDL3.3	5.49E-4	0	0.00266	0	7.55E-4	0
JEF2.2	5.97E-4	5.53E-5	0.00309	4.38E-4	0.00379	0.00133
UKFY3.5	**5.29E-4**	**5.03E-5**	**0.00265**	**4.84E-4**	**0.00346**	**8.02E-4**

51- Sb- 125



Interest: Burnup indicator

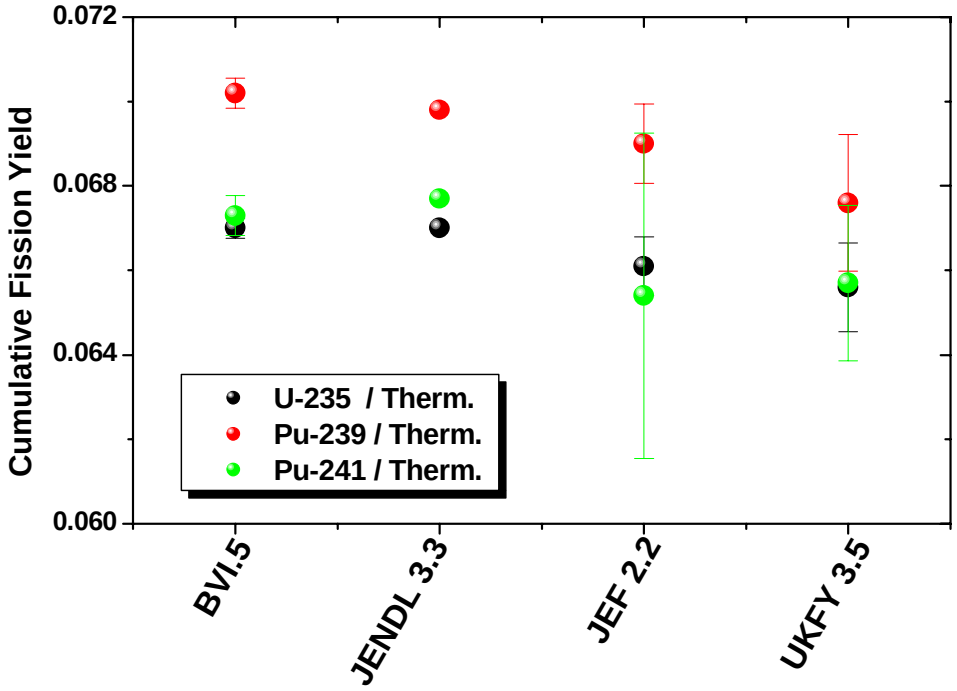
Integral trend [3]: Strong overestimation for the Pu-isotopes in JEF2.2

Comments:

- The strong overestimation in JEF2.2 for Pu239 has been corrected in UKFY3.5, but not for Pu241
- Uncertainties on Pu-241 data seems rather high

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	3.4E-4	9.53E-6	0.00112	8.93E-5	4.69E-4	5.16E-5
JENDL3.3	2.94E-4	0	0.00111	0	4.24E-4	0
JEF2.2	2.78E-4	1.66E-5	0.00207	3.8E-4	0.00266	9.33E-4
UKFY3.5	**2.6E-4**	**1.35E-5**	**0.00117**	**1.51E-4**	**0.00263**	**5.29E-4**

55- Cs- 133



Interest: Important absorbing FP (Burnup credit)

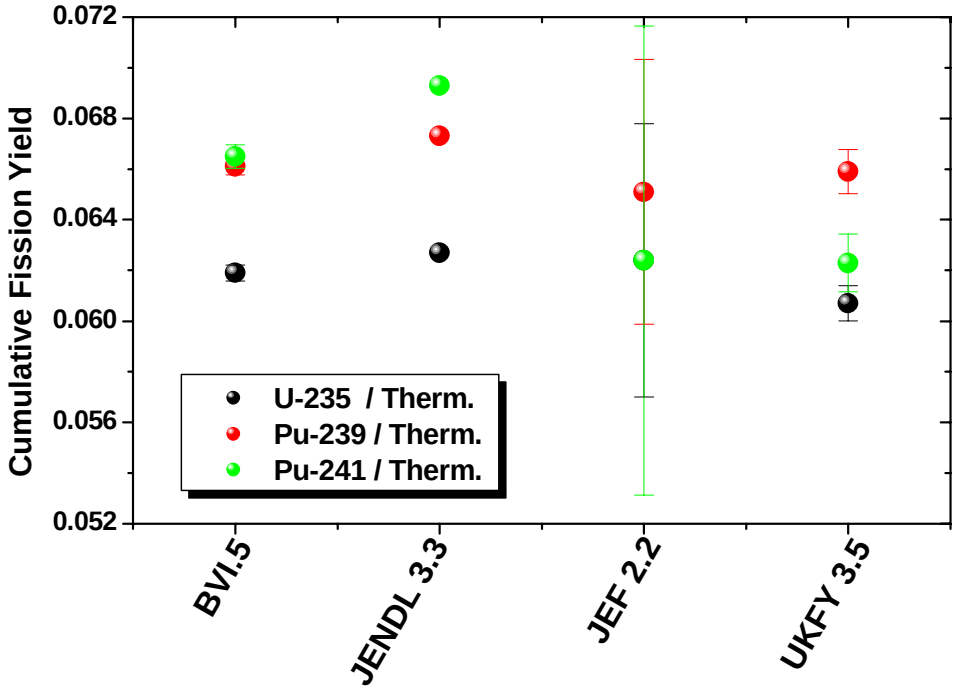
Integral trend [1]: JEF2.2 thermal yields are slightly (~2%) underestimated for U235 and Pu239

Comments:

- The integral trend is not taken into account since the values for U235 and Pu239 were decreased (compared to JEF2.2)

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.067	2.34E-4	0.0702	3.51E-4	0.0673	4.71E-4
JENDL3.3	0.067	0	0.0698	0	0.0677	0
JEF2.2	0.0661	6.98E-4	0.069	9.41E-4	0.0654	0.00385
UKFY3.5	**0.0656**	**0.00105**	**0.0676**	**0.00162**	**0.0657**	**0.00184**

55- Cs- 137



Interest: Burnup indicator

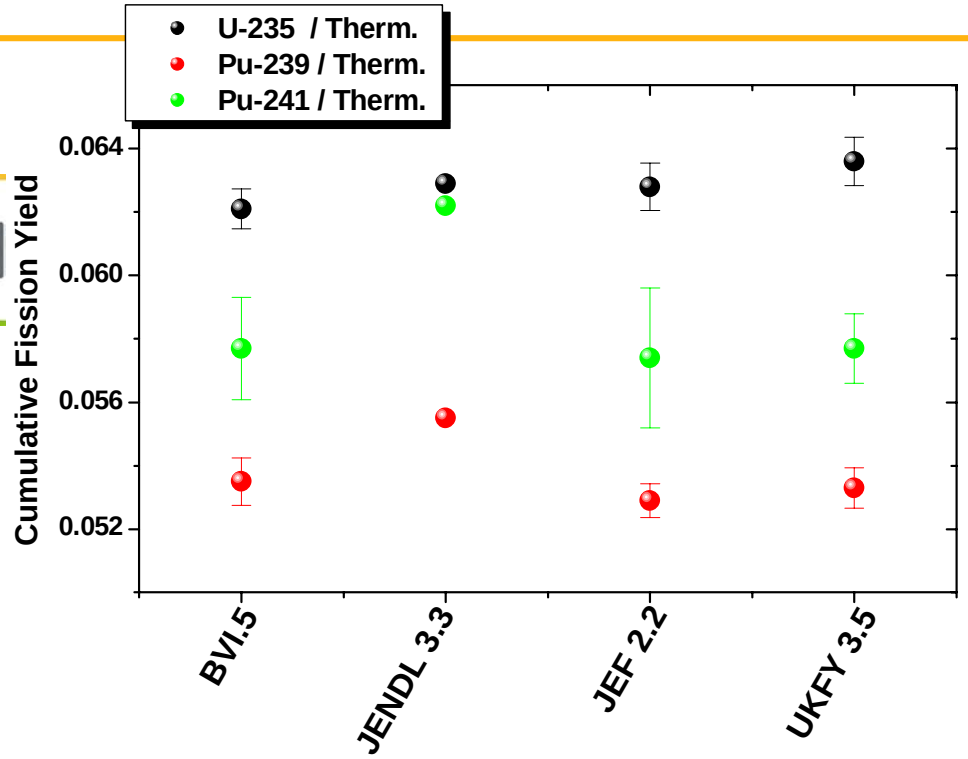
Integral trend [1]: JEF2.2 thermal yields are slightly (around 3%) underestimated for U235, Pu239 and Pu241

Comments:

- The integral trend is not taken into account
- The uncertainties have been strongly reduced in UKFY3.5 (compared to JEF2.2)

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.0619	3.09E-4	0.0661	3.3E-4	0.0665	4.66E-4
JENDL3.3	0.0627	0	0.0673	0	0.0693	0
JEF2.2	0.0624	0.00539	0.0651	0.00523	0.0624	0.00926
UKFY3.5	**0.0607**	**6.93E-4**	**0.0659**	**8.68E-4**	**0.0623**	**0.00114**

56- Ba- 140



Interest: Gamma peak-check experiment (Fission rate normalization)

Integral trend [1]: Ratio between the cumulative FY of U235 and Pu239 is found to be 1.14.

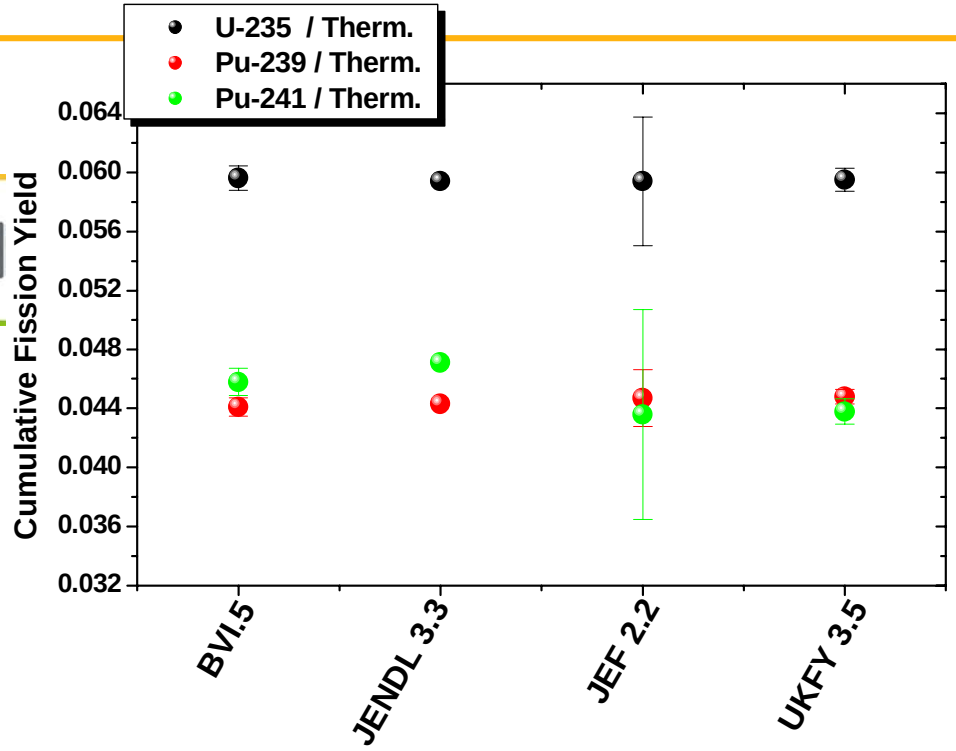
Using JEF2.2 (or UKFY3.5), this ratio is found to be 1.19, which is too high

Comments:

- JENDL3.3 values are recommended
- Problems observed in UKFY3.4 (too large uncertainties) have been corrected in UKFY3.5

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.0621	6.21E-4	0.0535	7.5E-4	0.0577	0.00161
JENDL3.3	0.0629	0	0.0555	0	0.0622	0
JEF2.2	0.0628	7.49E-4	0.0529	5.31E-4	0.0574	0.00221
UKFY3.5	**0.0636**	**7.63E-4**	**0.0533**	**6.4E-4**	**0.0577**	**0.0011**

58- Ce- 143



Interest: Absolute fission rate measurement ($CAPT_{U238}/FISS_{tot}$ conversion ratio)

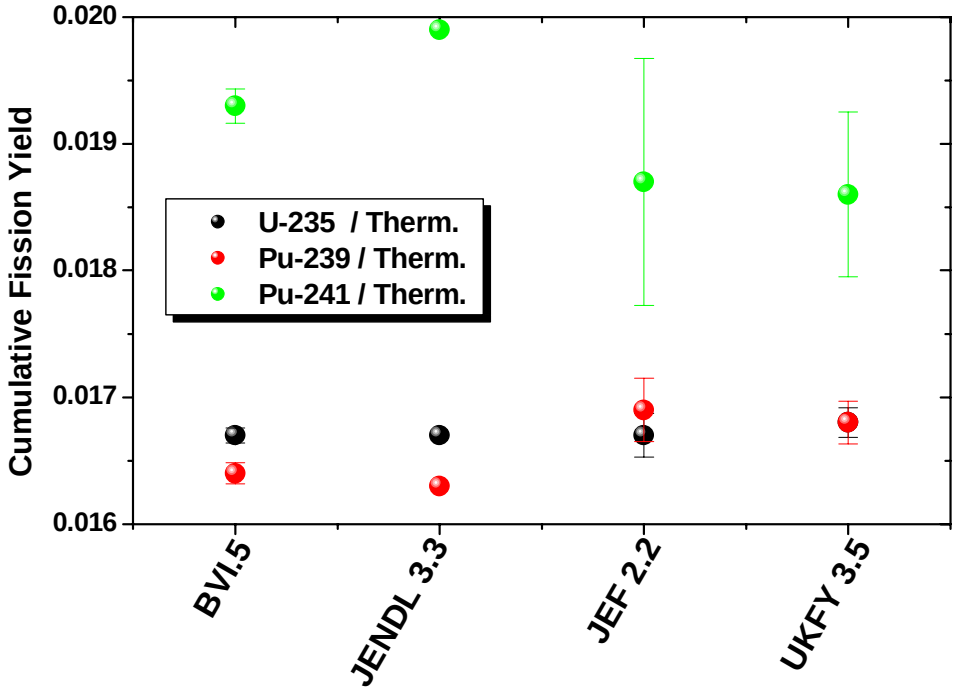
Integral trend [6]: Here, the cumulative FY in **B6.5** are underestimated: ~1% for U235 and ~2% for Pu239

Comments:

- The values given in UKFY3.5 on U235 and Pu239 follow the integral trend and are therefore satisfactory
- The uncertainties given in JEF2.2 are much higher than the one given in B6.5. It has been corrected in UKFY3.5

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.0596	8.34E-4	0.0441	6.18E-4	0.0458	9.16E-4
JENDL3.3	0.0594	0	0.0443	0	0.0471	0
JEF2.2	0.0594	0.00435	0.0447	0.00191	0.0436	0.0071
UKFY3.5	**0.0595**	**7.74E-4**	**0.0448**	**4.92E-4**	**0.0438**	**8.77E-4**

60- Nd- 148



Interest: Burnup indicator

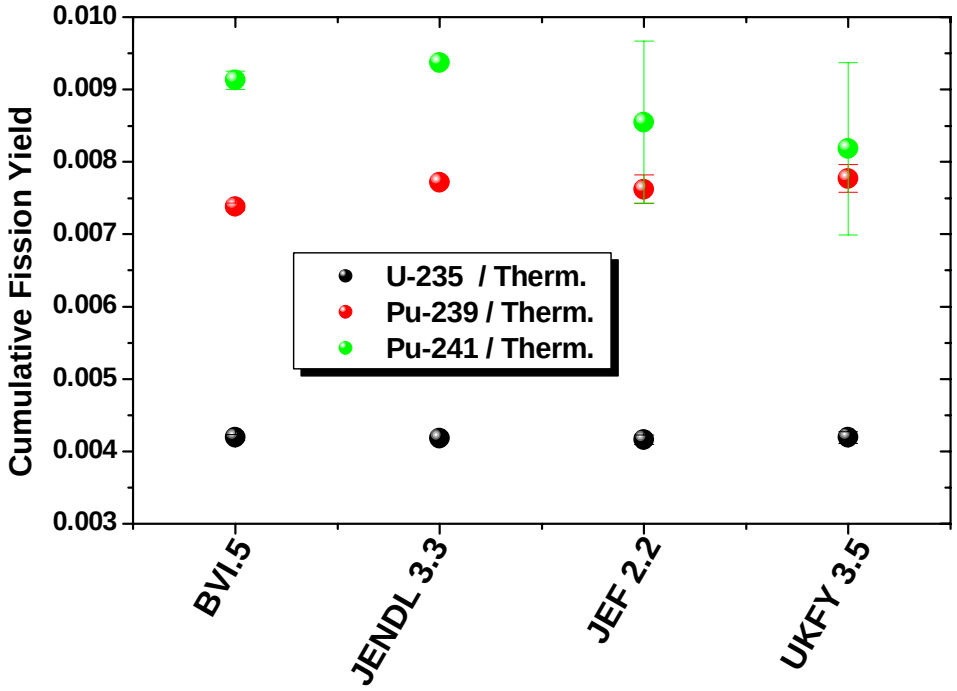
Integral trend [1,4]: The absolute values from B6.5 are recommended for the 3 reactions

Comments:

- The Pu239 values should be corrected in UKFY3.6
- The uncertainties in UKFY3.5 seem to be more realistic than in B6.5

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.0167	5.86E-5	0.0164	8.21E-5	0.0193	1.35E-4
JENDL3.3	0.0167	0	0.0163	0	0.0199	0
JEF2.2	0.0167	1.72E-4	0.0169	2.52E-4	0.0187	9.73E-4
UKFY3.5	**0.0168**	**1.18E-4**	**0.0168**	**1.68E-4**	**0.0186**	**6.5E-4**

62- Sm- 151



Interest: Important absorbing FP (Burnup credit)

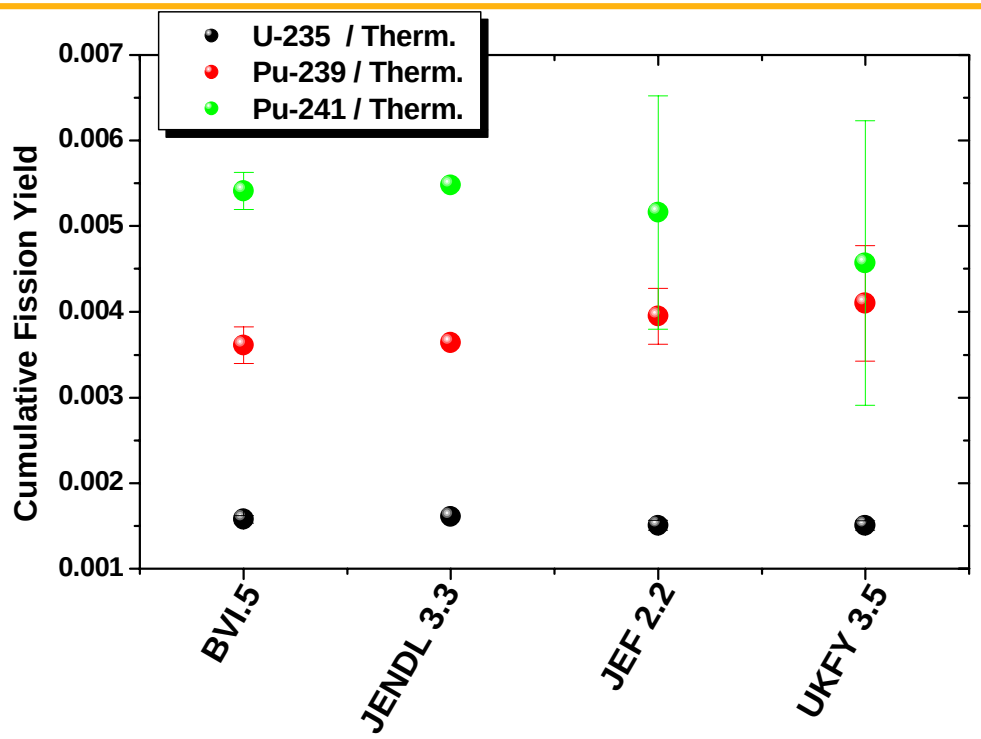
Integral trend [1,2]: Cumulative fission yields over estimated (around 2% for U235 and Pu239) in JEF2.2

Comments:

- The UKFY3.5 value for Pu239 does not follow the integral trend and should be revised.

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.00419	4.19E-5	0.00738	5.17E-5	0.00913	1.28E-4
JENDL3.3	0.00418	0	0.00772	0	0.00937	0
JEF2.2	0.00416	6.63E-5	0.00762	1.98E-4	0.00855	0.00112
UKFY3.5	**0.00419**	**7.96E-5**	**0.00777**	**1.94E-4**	**0.00818**	**0.00119**

63- Eu- 153



Interest: Important absorbing FP (Burnup credit)

Integral trend [2]: Cumulative fission yields over estimated in JEF2.2 (around 10% for U235 and Pu239)

Comments:

- For Pu239, the UKFY3.5 value was increased (compared to JEF2.2). It does not follow the integral trend. The value given in B6.5 is recommended.
- For U235, the UKFY3.5-value should be also decreased.

	U 235 / Therm.		Pu 239 / Therm		Pu 241 / Therm.	
	FYcum	Error	FYcum	Error	FYcum	Error
ENDFB6.5	0.00158	4.43E-5	0.00361	2.17E-4	0.00541	2.16E-4
JENDL3.3	0.00161	0	0.00364	0	0.00548	0
JEF2.2	0.00151	5.9E-5	0.00395	3.25E-4	0.00516	0.00136
UKFY3.5	0.00151	5.58E-5	0.0041	6.73E-4	0.00457	0.00166

Conclusion and outlook

- Various important FP for reactor and fuel cycle applications have been investigated and compared with the integral trends. Some corrections are proposed for the UKFY3.6 evaluation file.

- Using UKFY3.6 and the new Decay Data file, the energy released in fission (delayed components: EB, EGD, ENU) could be calculated in a consistent way and added in File 1 MT458.

References

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