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Subgroup 37- fission product yield evaluation

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Background

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- New experiments
- New models
- Uncertainity propagation/Covariance
- New needs/uses
- Status of subgroup
- Plans for completion

New Experiments

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- Traditional independent or cumulative
  (A_f,Z_f) [*,f] → (A,Z) or (A,Z,I)
  - TUNL, PROFIL, …
- New experiments:
  - (A_f,Z_f) [*,f] → $(\overline{A},\overline{Z};\Delta\overline{A},\Delta\overline{Z})$
    SPIDER, STEFF, …
  - (A_f,Z_f) [*,f] → (A,Z,I)
    IGISOL, Penning trap, {Electrostatic mirrors?}, …
  - $(A_?,Z_?)$ [*,f] → $(\overline{A},\overline{Z})$ or (A,Z,I)
    Coulombic excitation, SOFIA, VERDI, …

New Models

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- GEF model by K-H Schmidt
  - 21 physics parameters
  - Physics and Mathematics rules then used to generate fission yields
  - Parameters then “adjusted” to give best fit to all fissioning systems simulataneously
  - Not fitted to individual system or its data!
  - Often as good as purely empirical fitting to data
  - Some new physics, but mostly joining older work together
  - Link to codes considering expt data e.g. MATCH
- Other new physics models
  - Consider only part of problem and little published to date
  - Need more information ...

Uncertainity/Covariance

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Question

"How accurate are these calculations?"

- Over-predictions result in design conservatisms (shielding, cooling, unnecessary throughput constraints , non-optimum waste forms) and thus higher costs.
- Under-predictions can result in plant shutdowns, reduced throughputs, missing project deliverables, longer time scales and thus higher costs.

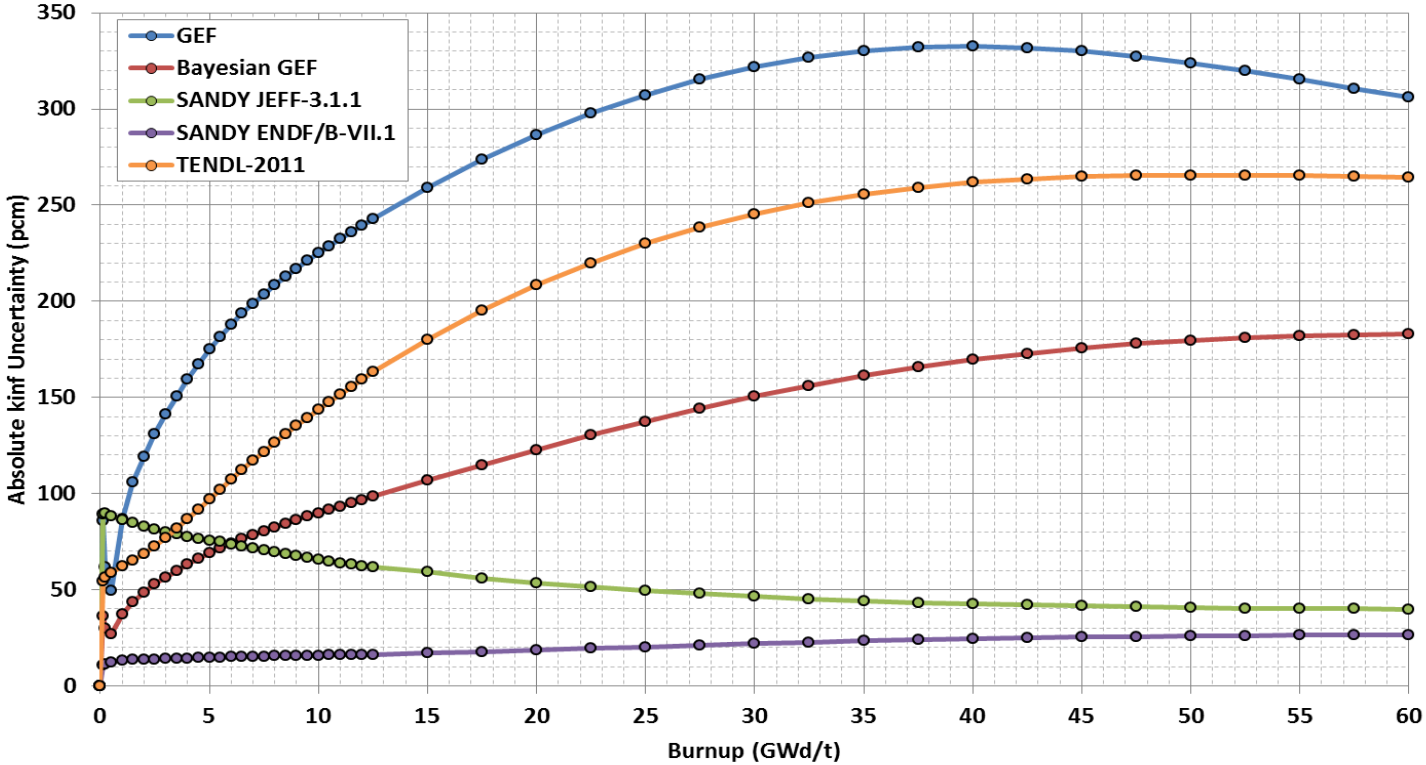
The problem

- The production and destruction of all nuclides are governed by the standard equations:

$$\frac{dN_i}{dt} = -\lambda_i N_i + \sum_i \lambda_j N_j B_{j,i} - \sum_l N_i \sigma_{i,d} \phi + \sum_m N_m \sigma_{m,i} \phi + \sum_k N_k \sigma_{k,f} \phi Y^i_{k,i}$$

- Note use of independent yields, but most measurements are cumulative yields (95% unmeasured and from models).

Reactivity Uncertainty



- Different order of magnitude for the kinf uncertainty (no cross-correlations used here)
- The Bayesian feedback ("Bayesian GEF" curve) reduces the kinf uncertainty compared to the GEF method
- The SANDY method creates correlations but also reduces the uncertainty (consistent with chain FY uncertainties) that explains the low uncertainty on kinf

Nuclide Composition Uncertainty

- GEF uncertainties are propagated from the fission observable parameters (and are totally independent from the uncertainties stored in evaluations)
- Without correlations, the propagation of TENDL-2011 uncertainties gives rather important uncertainties on some nuclide compositions (^{133}Cs, ^{134}Cs, ^{129}I)
- The effect of the Bayesian feedback is clearly a reduction of the uncertainty for almost all nuclides.
- Unless for few isotopes, the uncertainties found using the SANDY sampling are smaller than those found with the "Bayesian GEF" sampling which highlights the effect of the uncertainty reduction.
- The FY and the chain yields uncertainties are different for ENDF/B-VII.1 and the JEFF-3.1.1. It implies different results using the SANDY code with the two libraries
- JEFF-3.1.1 FY uncertainties lead to generally higher uncertainties

Nuclide	TENDL 2011	GEF	Bayesian GEF	SANDY ENDF/B-VII.1	SANDY JEFF 3.1.1
^{90}Sr	1.34	3.61	2.36	3.58	9.32
^{95}Mo	1.37	3.35	1.78	0.53	0.86
^{99}Tc	1.40	2.62	2.02	3.89	1.05
^{101}Ru	4.62	3.74	1.63	0.68	1.81
^{103}Rh	2.32	6.56	6.66	1.28	2.35
^{109}Ag	36.43	9.89	11.83	8.22	3.44
^{129}I	59.01	11.36	11.50	6.32	6.50
^{131}Xe	2.59	6.38	5.45	3.24	9.28
^{135}Xe	4.18	2.78	2.14	0.50	1.87
^{133}Cs	22.94	4.19	2.58	3.09	3.31
^{134}Cs	22.28	4.18	2.20	2.84	3.35
^{137}Cs	1.51	2.83	1.86	0.31	0.76
^{144}Ce	1.53	3.59	3.04	0.31	0.60
^{142}Nd	1.89	3.17	1.87	0.76	1.59
^{143}Nd	1.39	2.71	2.04	0.44	0.74
^{144}Nd	0.93	3.51	2.05	0.22	0.54
^{145}Nd	1.36	4.70	2.61	0.37	0.82
^{146}Nd	1.25	5.62	2.91	0.63	0.62
^{148}Nd	1.86	8.07	5.37	0.85	0.58
^{147}Sm	1.92	6.98	3.98	0.54	1.08
^{149}Sm	2.20	7.60	7.25	0.46	1.09
^{150}Sm	2.10	8.53	6.04	0.44	1.00
^{151}Sm	2.30	10.36	9.16	0.64	1.57
^{152}Sm	1.95	12.48	10.88	0.58	1.26
^{153}Eu	1.84	13.24	11.11	0.81	1.25
^{154}Eu	1.92	13.87	11.32	0.85	1.23
^{155}Eu	2.19	15.01	12.38	1.00	1.58
^{155}Gd	2.22	15.84	12.62	0.99	1.41
^{156}Gd	2.97	18.57	14.07	1.23	1.72
^{157}Gd	7.08	26.62	19.43	1.42	3.18
^{158}Gd	12.12	37.66	26.14	2.84	3.50

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New Uses

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- Tradiationally use for
  - Inventory calculations (wastes, fuel cycle)
  - Activity
  - Radiation emission (beta, alpha, gamma)
  - Decay heat

- “New” uses
  - Uncertainities
  - Keff calculation with burnup
  - Anti-neutrino
  - ...

Status of subgroup

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- Held 4 meetings
  - 18 presentations
  - Active discussions
  - Quite a few new ideas developed by participants
  - Some recommendations suggested
    - Benchmark for FY covariances
    - Maintain measurement capability
    - Develop new evaluation procedures
- Need draft document framework
  - Encourage contributions
  - Get updates on work, some published?
  - Get agreement on recommendations

Status of subgroup

- Status can be described at “writing up” stage
  - Last formal meeting held this week.
  - Now need to prepare report

  Plan
- Prepare draft framework by early August
- Ask for volunteers to review/add to text
- Discuss with individuals at ND2016
- Produce consensus document by November
- Discussion of Draft document via teleconf on 1st December 2pm (tbc).
- Finalise by January 2017 for issue prior to next meeting