Target Accuracy Requirements Exercise Proposed Approach and Next Steps

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Approach

- The exercise will follow different phases:
  - First Phase: Definition of TAR (current)
    - First step: selection of target reactors
    - Selecting integral parameters and associated TAR
  - Second Phase: Uncertainty Quantifications
    - For all selected parameters and target reactors compute uncertainty for selected isotopes and reactions possibly using different libraries and associate covariance data. For contribution and computation and tables use guidelines indicated in https://www.oecd-nea.org/science/wpec/sg33/benchmark/format/Uncertainty_contributions.pdf.
    - Analyses of uncertainty assessment should select isotopes, and reactions where to look at the energy contribution using the 7 groups energy structure
    - Produce a first list of requirements based on previous step

Example of Uncertainty Table

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- **Some remarks:**
  - Negative values are imaginary ones that give negative contributions when squared
  - Sum are statistically made (square root of square sums) with correlations among two terms equally (Solomonic) split.
  - The minimal list of reactions should include also fission spectrum and elastic $\bar{\mu}$ (P_1). Other possible terms: (n,2n), inelastic $\bar{\mu}$, delayed ν and χ.

Isotope	σ_{cap}	σ_{fiss}	ν	σ_{el}	σ_{inel}	Total
U238	50	-2	32	13	12	62
PU239	-29	-57	-10	-1	-13	-66
PU240	93	71	108	14	46	167
FE56	40	0	0	28	38	62
PU241	93	61	37	1	21	120
PU242	88	37	31	2	5	101
NA23	5	0	0	-5	35	35
O16	7	0	0	23	3	24
Total	169	83	122	41	73	239

Approach

- Third Phase: Performing TAR with inverse approach
  - First step: use 7 groups data, no correlation among covariances (only variances), λ cost parameters equal to 1, and 1 reactor and one parameter (recommended: K_{eff}).
  - Second step: use variable λ cost parameters (to be defined by reaction (isotope?))
  - Third step: repeat first and second step for one system and all parameters.
  - Fourth step: use all systems and parameters together
  - Fifth step: introduce correlations
  - At any step: if problem is untreatable (too many variables) consider using only 98% of total uncertainty (SG26 approach).

Target accuracy requirements via sensitivity analysis

To establish priorities and target accuracies on data uncertainty reduction, a formal approach can be adopted: define target accuracy on design parameter and find out required accuracy on data (the "inverse" problem).

The unknown uncertainty data requirements d_i can be obtained solving the following minimization problem :

$$\sum_i \lambda_i / d_i^2 = min \quad i = 1, \ldots I$$

with the following constraints :

Correlation terms

$$\sum_i S_{ni}^2 d_i^2 + \sum_{ii'} S_{ni} d_i Corr_{ii'} d_{i'} S_{ni'}^{+} \leq \left(R_n^T\right)^2 \qquad n = 1, \ldots N$$

S_{ni} are the sensitivity coefficients for the integral parameter R_n, $Corr_{ii'}$ is the correlation value between variable i and i', and $R^T{}_n$ are the target accuracies on the N integral parameters

λ_i are "cost" parameters related to each σ_i and should give a relative figure of merit of the difficulty of improving that parameter (e.g. reducing uncertainties with an appropriate measurement).

SG46 Suggested Energy Grid

- **For the SG46 we suggest a subset of the 33 group energy structure with only 7 groups (based on physical considerations). Advantages:**
  - **A more compact set of information**
  - **Less number of variables that helps solving the inverse problem**

Group	Upper Energy	Group	Upper Energy
1	$1.96403\ 10^{7}$	5	$2.03468\ 10^{3}$
2	$2.23130\ 10^{6}$	6	$2.26033\ 10^{1}$
3	$4.97871\ 10^{5}$	7	$5.40000\ 10^{-1}$
4	$6.73795\ 10^{4}$		

Reactions, Cost Parameters λ, and Isotopes

- First round with λ =1 for all reactions. Then, reactions (we need input from differential measurement experts: A. Plompen?):
  - Elastic λ=1 (reference)
  - Fission λ=?
  - Capture (n,γ) λ=?
  - Inelastic λ=?
  - μ, Elastic mubar λ=?
  - χ, Fission Spectrum λ=?
  - ν, Nubar λ=?
- Should we select only a limited number of isotopes? If yes, then: ^{52}Cr, ^{56}Fe, ^{58}Ni, ^{235}U, ^{238}U, ^{239}Pu + coolant. To these add isotopes that, in your judgement, are relevant to the investigated system, e.g.: ^{10}B (if control rods), ^{16}O (if oxide fuel), ^{12}C (if carbon moderated), ^{35}Cl (if chloride salt), minor Pu isotopes and minor actinides (if actinide burner), etc.