Status Report on the CSEWG Effort to Create Templates of Expected Measurement Uncertainties

CSEWG, Covariance Session 11/30/20

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A big thank you to all co-authors on the template paper and the CSEWG experiment committee!

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LA-UR-20-29504

Templates of expected measurement uncertainties provide:

- Listing of expected unc. for a specific measurement type: This can be used by experimentalists as a check-list before the release of their data, or by evaluators to counter-check whether all pertinent uncertainties were provided for various experiments.

- Recommended values of uncertainties if they are not provided for an experiments. These unc. values can be used for evaluations if they cannot be otherwise estimated.

- Estimates of correlation coefficient between unc. of the same and different experiments for evaluation purposes.

This effort was started in May 2019 by the CSEWG covariance and experiment sessions. It is expected to be finished in a few months.

(n,tot) and (n,g) templates are in their last review stage. Lead: A. Lewis.

(n,tot) template

Uncertainty source	TOF	Mono-energetic
Background (K)	> 3	–
In-scattering correction	–	20
Target-number density (metal)	0.1–1	0.1–1
Target-number density (powder)	2–5	2–5
Target-number density (liquid)	2–5	2–5
Flux normalization (N_T)	< 1	–

Uncertainty source	TOF	Mono-energetic
Counting statistics	Uncorrelated	Uncorrelated
Neutron-energy resolution	Gaussian	Strongly correlated
Resolution function	Gaussian	–
Background (K)	Fully correlated	–
Background (Calculated or measured)	Strongly correlated	–
In-scattering	–	Strongly correlated
Room return (β)	–	Fully correlated
Other background (γ_1, γ_2, ζ)	–	Gaussian
Target-isotope-number density	Fully correlated	Fully correlated
Flux normalization (N_T)	Fully correlated	Uncorrelated
Fluctuation correction (F_T)	Gaussian	–

(n,gamma) template

Uncertainty source	TAS	TED
Flux normalization (N_γ)	$\leq$0.3	$\leq$0.3
Efficiency (same isotope or validated)	$\leq$2	$\leq$2
Efficiency (other)	$\geq$3	$\geq$3
Fit background (k_γ or B)	$\leq$3	$\leq$3
Target isotope number/density (metal)	0.1–1	0.1–1
Target isotope number/density (powder)	2–5	2–5
Target isotope number/density (liquid)	2–5	2–5
Sample composition (stable, common isotope)	0.1–0.3	0.1–0.3
Sample composition (radioactive, common isotope)	1–2	1–2

Uncertainty source	PG	AA	AMS
Neutron energy	1	1	1
Neutron flux (reference reaction)	2-5	2-5	2-5
Neutron flux (AP)	1-3	1-3	1-3
Neutron flux (direct)	≥ 3	≥ 3	≥ 3
Gamma detector efficiency (<0.2 MeV)	4	4	4
Gamma detector efficiency (0.2 - 2.6 MeV)	2	2	2
Gamma detector efficiency (>2.6 MeV)	5	5	5
Charged-particle detector efficiency	—	2	—

Currently being re-worked according to co-authors comments.

PFNS and nu-bar templates are in their last review stage. Lead: D. Neudecker

PFNS

Unc. source	Shape (%)	Clean-ratio shape (%)	Ratio-calibration shape (%)
δc	Must be provided	Must be provided (δc_s & δc_m)	Must be provided (δc_s & δc_m)
δb	0.2–3	0.2–2	0.2-3 for both
δm	1–20 (not corrected)	0.1–5 (not corrected)	1–20 (not corrected, both)
	0.1–3 (corrected)	0–0.8 (corrected)	1–3 (corrected, both)
$\delta \varepsilon$	2–7 (efficiency)	Cancels	Unc. in determining χ_m
	0–10 (response not folded)	-	0-10 both (response not folded)
δa	0.1	0.1	0.1
$\delta \tau$	0.1	0.1	0.1 for both
Nuclear data	0.1–5 (simulations)	0–0.5 (simulations)	0.1–5 both (simulations)
	-	From libraries (reference)	From libraries (reference)
δt	2.5 ns	2.5 ns both	2.5 ns both
ΔL	2 mm	2 mm both	2 mm both
$\delta \omega$	Impurity-level dependent	Both samples	Both samples

Unc. source	Cor(Exp$_i$,Exp$_i$)	Cor(Exp$_i$, Exp$_j$) $i \neq j$
δc	Diagonal	None
δb	Gaussian	Facility and method dependent
δm	Gaussian anti-correlated	Facility and method
	around 2T	dependent
$\delta \varepsilon$	Gaussian	Depends on ε determination
δa	Gaussian	Gaussian
$\delta \tau$	Full	0
Nuclear data	From libraries	From libraries
δt	From TOF $\rightarrow E_{\rm out}$ transformation	0
ΔL	From TOF $\rightarrow E_{\rm out}$ transformation	0
$\Delta \omega$	Dependent on shape difference between main and impurity PFNS	Sample/ method dependent

Prompt/ Total Fission Neutron Multiplicity

Unc. source	Absolute (%)	Ratio (%)	Cor(Exp$_i$,Exp$_i$)	Cor(Exp$_i$,Exp$_j$)
δc	Must be provided	Must be provided (δc & δc^m)	Diagonal	None
δc_{DG}	0.1	0.12%	Full	Full
δb	0.15	0.5%	Gaussian	0.2 for same n source
				0 otherwise
δc_{ff}	-	0.22% (high α-activity sample)	Gaussian	0.2
	-	0.15% (low α-activity sample)		
δc_{FE}	0.1%	-	Gaussian	0.2
$\delta \omega$	see Table XII	see Table XII	0.9	0.9 (same method & isotope)
				0.1 (different isotope)
$\delta \tau$	0.1%	0.08%	Full	Low ($\sim$ 0.2)
$\delta \varepsilon_\gamma$ & $\delta \varepsilon_c$	0.2	N/A	Gaussian	Gaussian
$\delta \chi$	0.23	0.16%	Gaussian	Full (same $E_{\rm inc}$)
		0.5% (2$^{\rm nd}$-chance fission)		Gaussian (different $E_{\rm inc}$)
δL_n	0.2	N/A	Full	0.5
δa	N/A (isotropic)	0.01–0.3%	0.8–1.0	0.6
		0.5% at 2$^{\rm nd}$ c.f. and > 10 MeV		
$\delta \overline{\nu}^m$	N/A	From libraries/reference	Full	Full
δd	N/A (point source)	0.1%–0.3%	Full	0.8–0.9 (not corrected)
$\delta d_{s/m}$	N/A	0.05 %	Full	None
$\Delta E_{\rm inc}$	-	Estimate from similar facilities	Full in $E_{\rm inc}$ space	0
		at the same $E_{\rm inc}$		

Special thanks to: Chi-Nu, A. Carlson, P. Marini, J. Taieb

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(n,xn) template by J. Vanhoy and R.C. Haight in last review stage.

Unc. source	Monoenergetic	WNS
Timing-spread concerns		
Accelerator-beam-pulse width	< 1 ns	< 1 ns
Spread induced by neutron-production target	~ 1 ns	~ 1 ns
Spread due to sample size	$<< 1$ ns	$<< 1$ ns
Spread due to n/γ-transit time through detector	30–200 ns	30–200 ns
Response time due to detector size	~ 1 ns	~ 1 ns
Response time due to amplification stages	~ 1 ns	~ 1 ns
Digitization times	~ 1 ns	~ 1 ns
Deadtimes	Varies	Varies
Neutron-production target		
Overall (need full descrip. includ. cooling)	1%	$\sim$ 1%
Neutron-flux monitoring		
Fission chambers: deposit thickn. & uniform.	$\sim$ 1% (see [2])	$\sim$ 1% (see [2])
Fission chambers: σ_U(n,f)	$\sim$ 1% (see [6])	$\sim$ 1% (see [6])
Long counters	1–2%	
Liquid scintillators (For mono.)	1%	N/A
Scintillators (*e.g.*, Li-glass)	N/A	$<$ 1%
Sample		
Isotopic enrichment	$\sim$ 1%	$\sim$ 1%
Contaminants / Secondary contents	$\sim$ 1%	$\sim$ 1%
Chemical/Mechanical form and shape	$\sim$ 1%	$\sim$ 1%
Mass	$<<$1%	$<<$1%
Material uniformity	$\sim$ 1%	$\sim$ 1%
Dimensional measurements	0.3%	0.3%

FY (lead E. Matthews) and (x,cp) ("lead" D. Neudecker) in progress.

- FY: see separate talk by Eric Matthews.
- (x,cp): thanks to A.D. Carlson, R.C. Haight, M. Paris, D. Smith for their help to start this. I welcome any further help on this.

The templates are already being used in the field:

- It was discussed during the last **Neutron Data Standards** meeting that the templates will be used for counter-checking whether all pertinent uncertainties are considered for data in GMA and, if necessary, filling in missing uncertainties → see talk by R. Capote in covariance session.
- Used for PFNS and nu-bar **evaluations of ^{239}Pu** shown by D. Neudecker in the evaluation session.
- Will be used **as input for NEA WPEC SG-50** on developing an automatically readable, comprehensive and curated experimental reaction database starting from EXFOR:
  - to formulate what uncertainty sources should be stored in the database,
  - flag missing uncertainty sources for data exported from EXFOR into the database,
  - fill in missing uncertainty source for subjective corrections in the database.

  → see talk by A. Lewis in covariance session.

Summary:

- **The template effort is well underway.** The journal publication will be finished before spring. Once the templates are submitted, they will be published on the NNDC homepage for use by the community.

- **The templates are already being used for various evaluation efforts** (standards, LANL evaluations, etc.) and will be used for SG-50 to **identify which uncertainty sources should be stored in the SG50 experimental database derived from EXFOR, to flag missing uncertainties in past measurements and to add these missing uncertainties back into the subjective layer of the database.**

Thank you for your attention!

We gratefully acknowledge the support of the Advanced Simulation and Computing (ASC) program at Los Alamos National Laboratory.