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Uppsala experience of automatic data retrieval and covariance interpretation

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Developing an Automatically Readable, Comprehensive and Curated Experimental Reaction Database (ARC-CERD)

WPEC Subgroup 50 (SG50)

First attempt - Automatic interpretation of EXFOR database

- Both EXFOR and XC4 format used
  - information not complete,
  - interpretation of the databases is not straightforward.
- 6 rules to estimate random and systematic uncertainties.

P. Helgesson et al., “Combining Total Monte Carlo and Unified Monte Carlo: Bayesian nuclear data uncertainty quantification from auto-generated experimental covariances,” Progress in Nuclear Energy, vol. 96, pp. 76–96, Apr. 2017

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The rules to interpret EXFOR / XC4

1. EXFOR entries with uncertainty less than 0.1% are discarded.
2. If only one uncertainty estimate is given for each experimental point, the point is assigned with both a random and a systematic uncertainty of this magnitude.
3. Energy resolution taken from XC4 or assumed to be 1%. Energy uncertainty assumed to be 0,5%
4. Systematic uncertainties set to at least 2 % and random uncertainties to at least 1 %
5. 1 mb extra uncertainties are added. 20 % extra systematic + 0,5 % extra random.
6. A uncertainty of 1% which is fully correlated for all experimental points within the same reaction channel is added.

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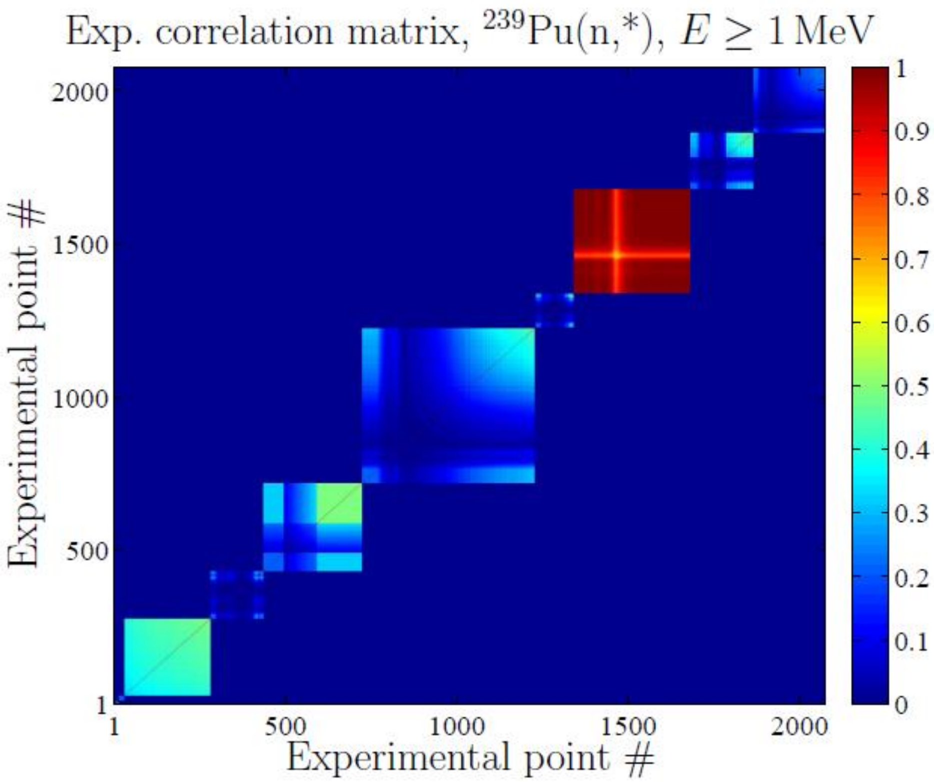
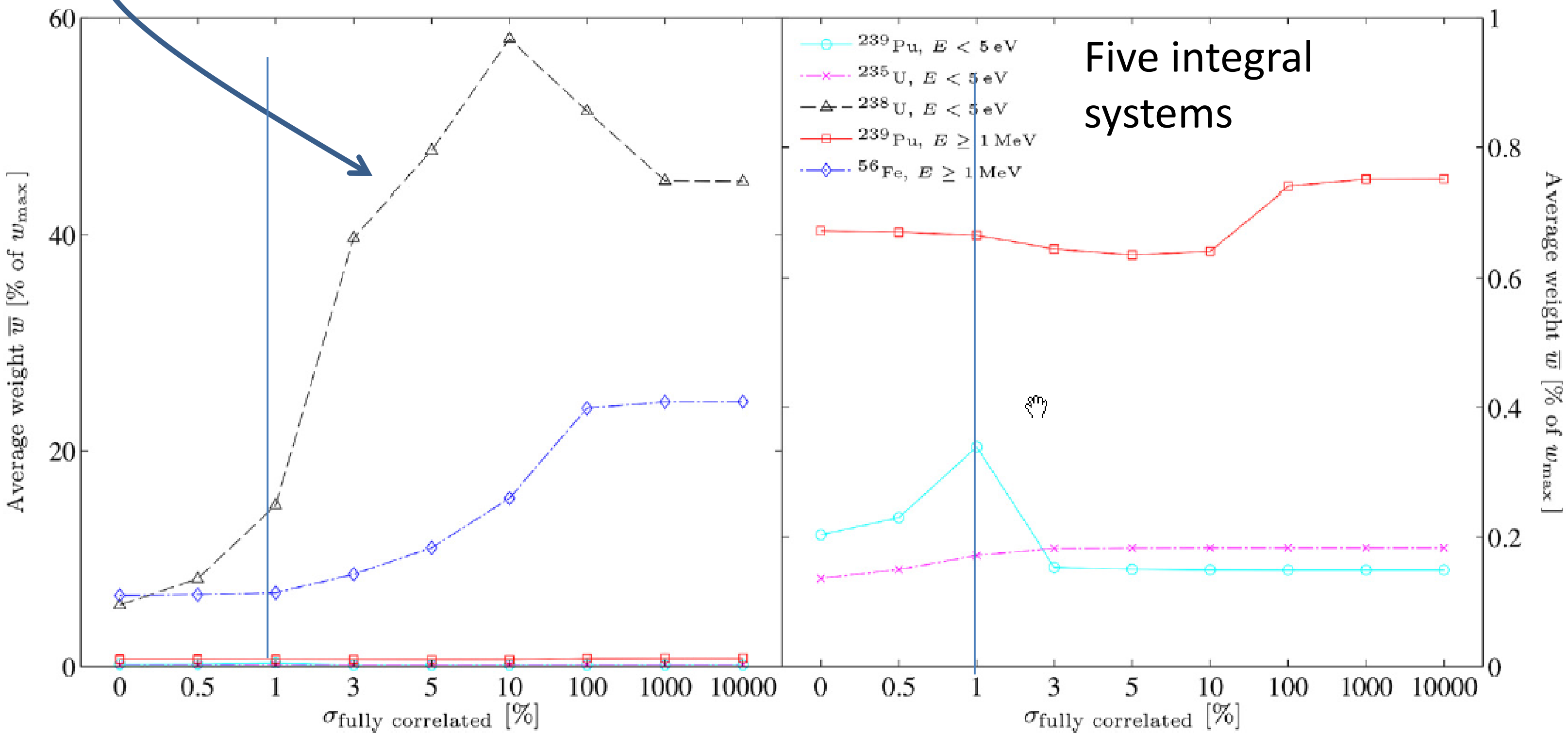
The matrix



- With a set of rules we interpret EXFOR and create exp-cov matrix.
- Is this enough?

Sensitivity to rules

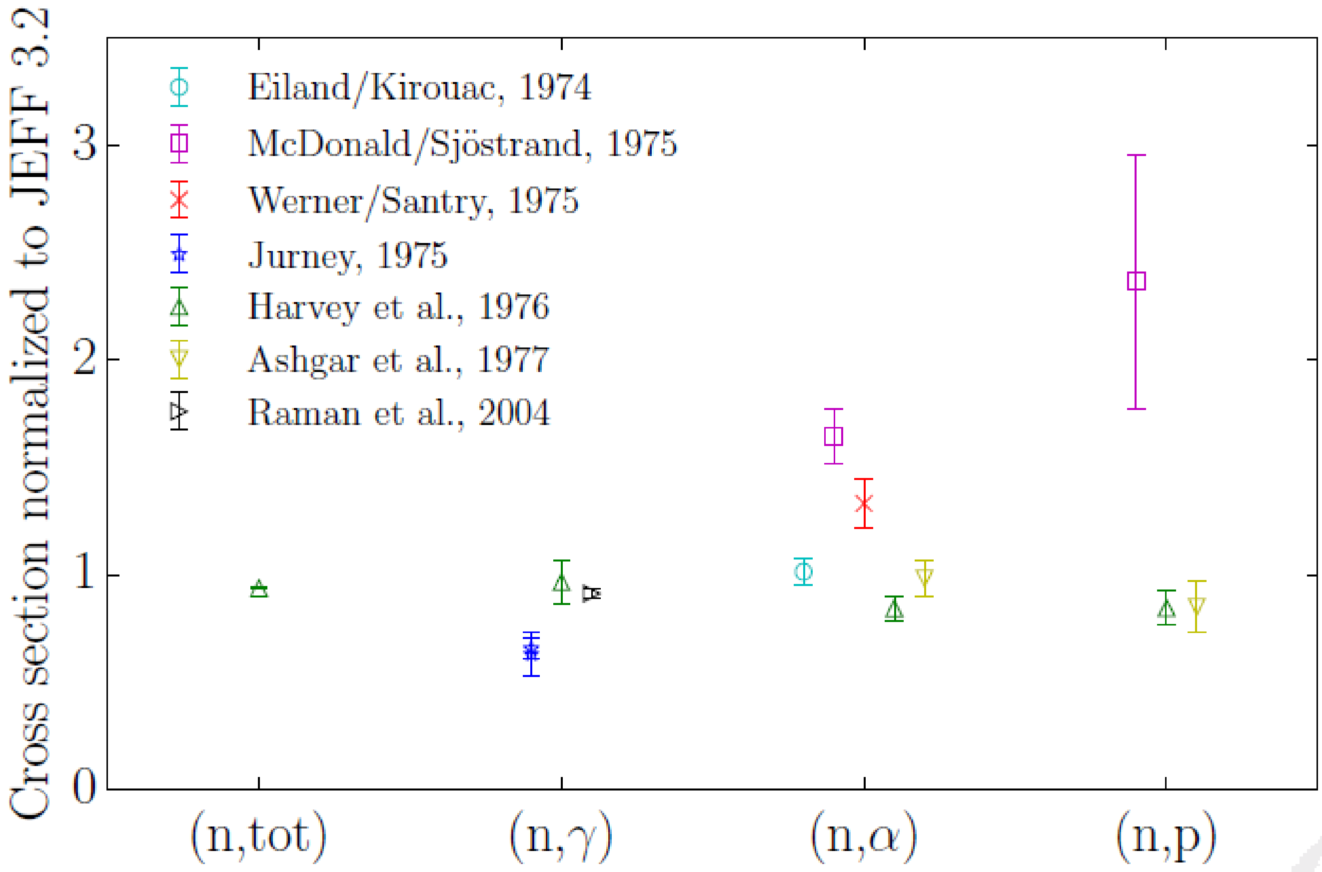
- Integral results insensitive to most of the rules.
- However, sensitive to some of the rules.



Take away message

- We already have an Automatically Readable, ~~Comprehensive and Curated~~ Experimental Reaction Database
- Current EXFOR / XC4 missing information to create an unambiguous exp-cov file using a rule based approach
- An ARC-CERD should focus to provide the information to which integral parameters are sensitive.

Level 3 - Corrections for Ni-59 (JEFF 3.3.)



P. Helgesson, H. Sjöstrand, and D. Rochman, "Uncertainty-driven nuclear data evaluation including thermal (n, α) applied to 59 Ni," Nuclear Data Sheets, vol. 145, pp. 1–24, Nov. 2017

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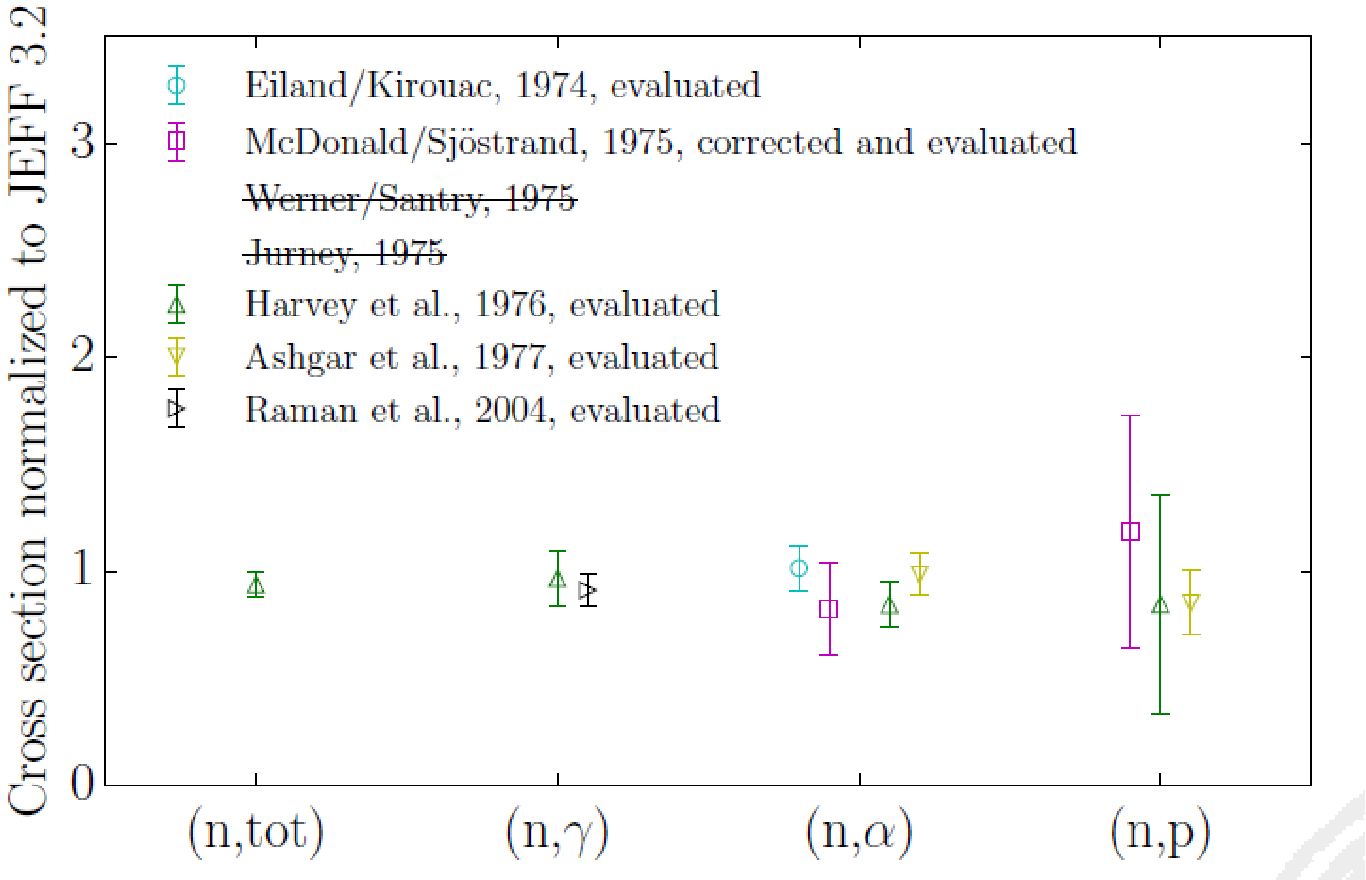

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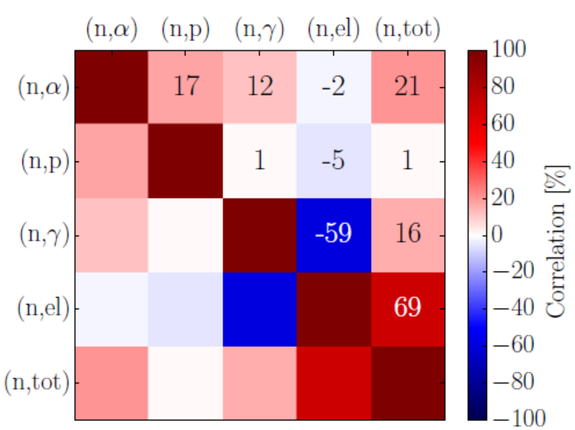
Common error components

Appendix	A.1	A.3		A.5				A.6				A.7
Reaction	(n,α_0)	(n,α_0)	(n,p_0)	(n,tot)	(n,γ)	(n,α_0)	(n,p_0)	(n,α_0)	(n,α_1)	(n,p_0)	(n,p_1)	(n,γ)
Est. [b]	13.7	11.1	2.0	92.28	78	11.4	1.43	13.1	0.188	1.34	0.10	73.7
Combined	$6.54^{\dagger}$	-	-	-	-	-	-	7.38	7.51	12.8	100	4.43
C	$*$	1.35	1.35	0.631	10.3	7.02	9.09	$*$	$*$	$*$	$*$	$*$
Backg.	$*$	1	50	$\sqrt{1^2+2^2}$	1	1	50	1	1	1	$*$	1
ϵ	3.20*	-	-	-	-	-	-	-	-	-	-	-
$\mathcal{N}$	5	-	-	5^e	5^e	5^e	5^e	-	-	-	-	-
N	-	2^a	2^a	-	-	-	-	2^a	2^a	2^a	$*$	$*$
d	-	3^b	3^b	-	-	-	-	3^b	3^b	3^b	$*$	4
ϕ	5.85	-	-	-	-	-	-	-	-	-	-	-
ϵ'/ϵ	-	2	2	-	2	2	2	2	2	2	$*$	2
$\mathcal{N}'$	-	-	-	-	5^f	5^f	5^f	-	-	-	-	-
N'	-	20^c	20^c	-	-	-	-	3^g	3^g	3^g	$*$	$*$
d'	-	6^d	6^d	-	-	-	-	4^h	4^h	4^h	$*$	4
ϕ'/ϕ	-	2^{α}	2^{α}	2^{**}	2^{β}	2^{β}	2^{β}	$*$	$*$	$*$	$*$	2
ς'	$0.14^{i\,\heartsuit}$	0.13^i	0.13^i	-	0.13^i	0.13^i	0.13^i	0.13^i	0.13^i	0.13^i	0.13^i	$0.21^{i\,\heartsuit}$
Ref. reaction	^{197}Au(n,γ)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{6}Li(n,t)	^{1}H(n,γ)$^{\diamond}$
Ref. value	$98.8^{\dagger\dagger}$	940	940	$940, 941^{\dagger\dagger}$	$940, 941^{\dagger\dagger}$	$940, 941^{\dagger\dagger}$	$940, 941^{\dagger\dagger}$	941	941	941	941	0.3326



Results reported to the NDS EXFOR correction system (IAEA)

- Reporting was smooth (by email). Required some manual intervention by Naohiko Otsuka.
- Only corrections to the cross-sections and uncertainties were reported. For common error components we reported: *”See also Table 2 of P.Helgesson et al., Nucl.Data.Sheets 145(2017)1, where partial uncertainties and their correlation properties are summarized ”*

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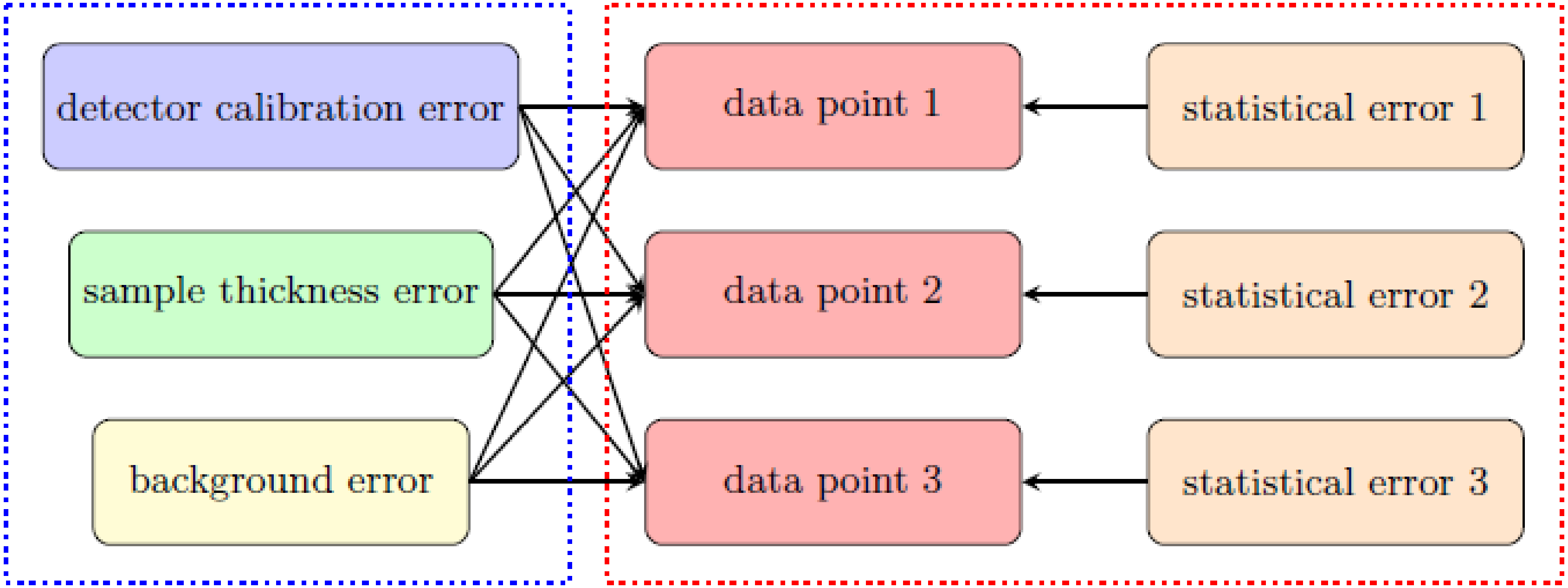
Take away message

- Determining correction factors and error components - time consuming.
- Information on the common error components necessary for the evaluation.
  - The information should be stored in “Layer 3”
- Information stored in NDS EXFOR correction system could potentially be automatically retrieved
  - However, information on common error components might get lost in automatic evaluation.

A new ND evaluation pipeline



- EXFOR → JSON stored in a MongoDB database
- Can handle common error components
- Does not contain: renormalization of experimental data according to the newest evaluations of monitor reactions
- A system ready to test any new features developed within this SG.

G. Schnabel, H. Sjöstrand, J. Hansson, D. Rochman, A. Koning, and R. Capote, "Conception and software implementation of a nuclear data evaluation pipeline", 2020

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Conclusions

- EXFOR, XC4 and NDS EXFOR correction system are great, but lacks some features.
- An ARC-CERD should
  - Prioritize information important for integral systems
  - Handle common error components
  - Allow automatic access to renormalization of experimental data according to the newest evaluations of monitor reactions
- UU has and will continue to contribute with experimental corrections to any ARC-CERD developed.

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References

- P. Helgesson et al., “Combining Total Monte Carlo and Unified Monte Carlo: Bayesian nuclear data uncertainty quantification from auto-generated experimental covariances,” Progress in Nuclear Energy, vol. 96, pp. 76–96, Apr. 2017, doi: 10.1016/j.pnucene.2016.11.006.
- P. Helgesson, H. Sjöstrand, and D. Rochman, “Uncertainty-driven nuclear data evaluation including thermal (n, α) applied to 59 Ni,” Nuclear Data Sheets, vol. 145, pp. 1–24, Nov. 2017
- G. Schnabel, H. Sjöstrand, J. Hansson, D. Rochman, A. Koning, and R. Capote, “Conception and software implementation of a nuclear data evaluation pipeline,” *arXiv:2009.00521* 2020; http://arxiv.org/abs/2009.00521.