EXFOR and templates: just a start towards good experimental uncertainty quantification for evaluations

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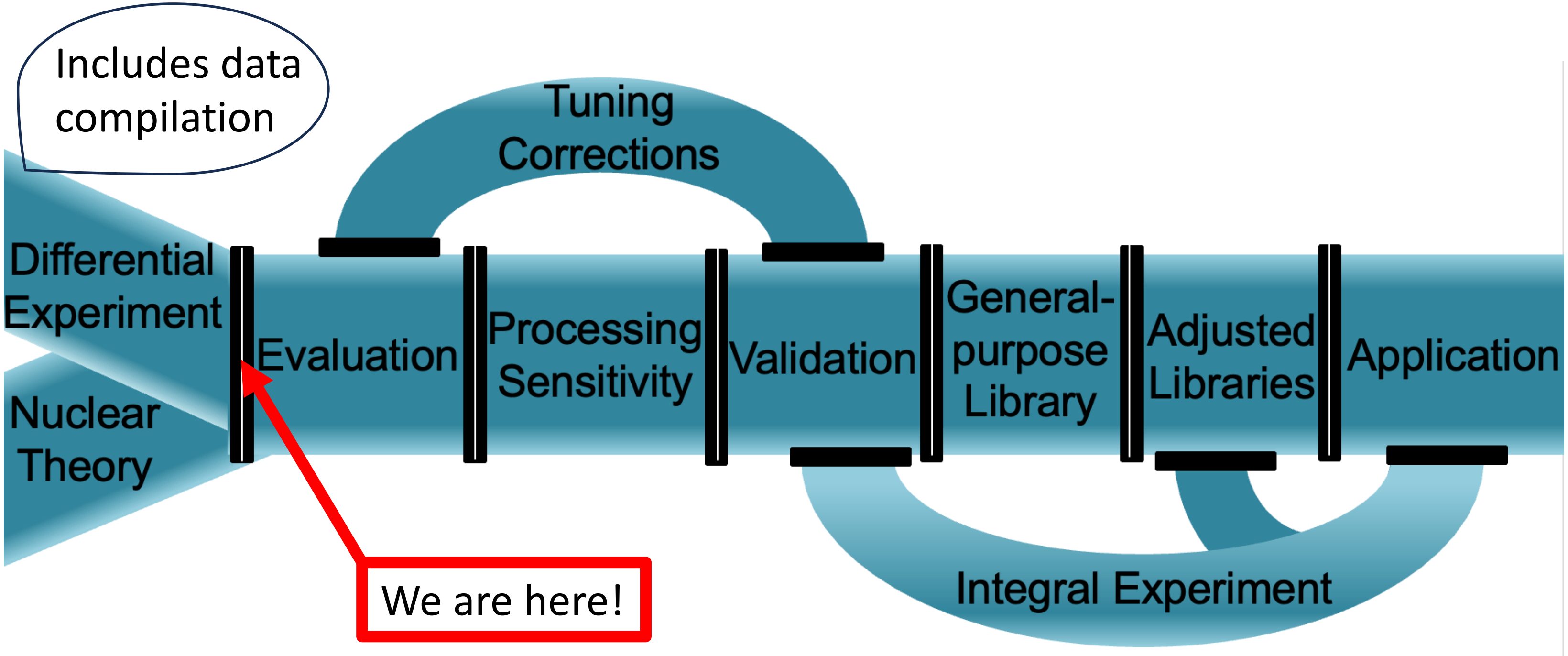
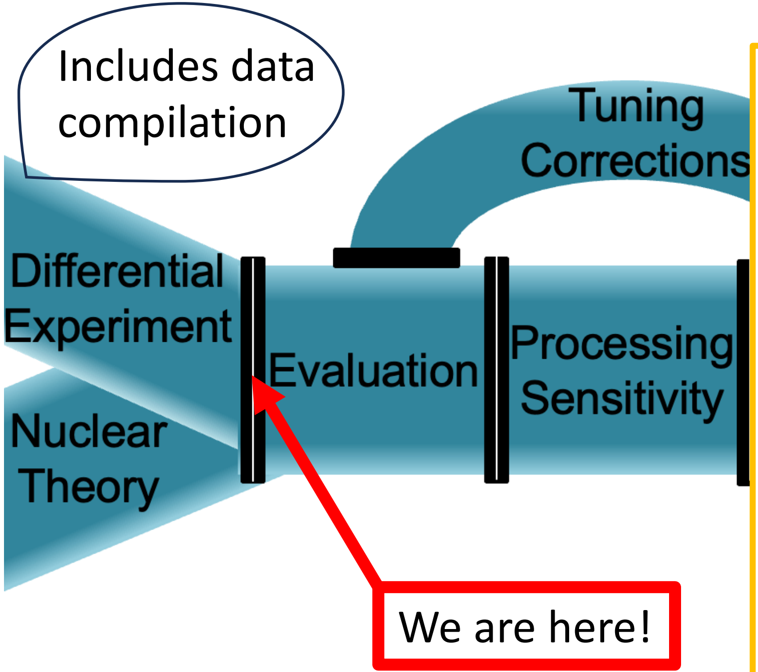
WANDA, February. 12, 25

LA-UR-25-21216

Where are we in the pipeline? We prepare experimental databases as input for evaluations.



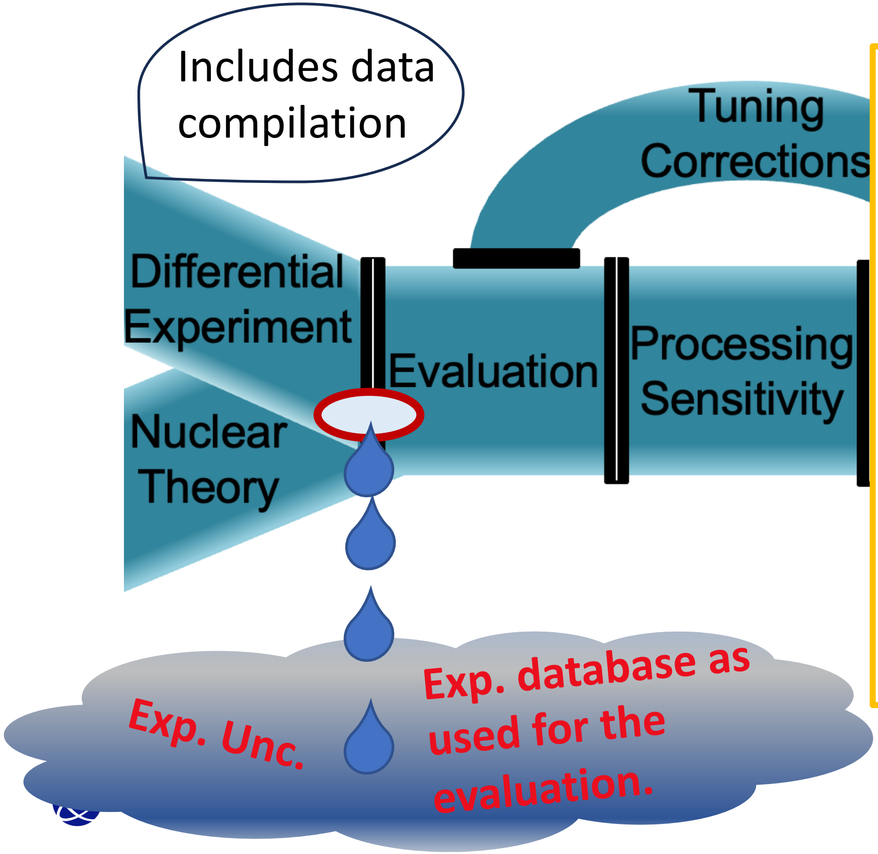
The preparation of an experimental database for evaluations is time-intensive.



Tasks:

- Create a database for evaluation starting from EXFOR
- Renormalize data to newest standard
- Remove outliers
- Estimate total uncertainties
- Bonus: Quantify bias using simulations and maybe AI/ ML

There are leaks in this part of the pipeline costing work time and biasing evaluations.



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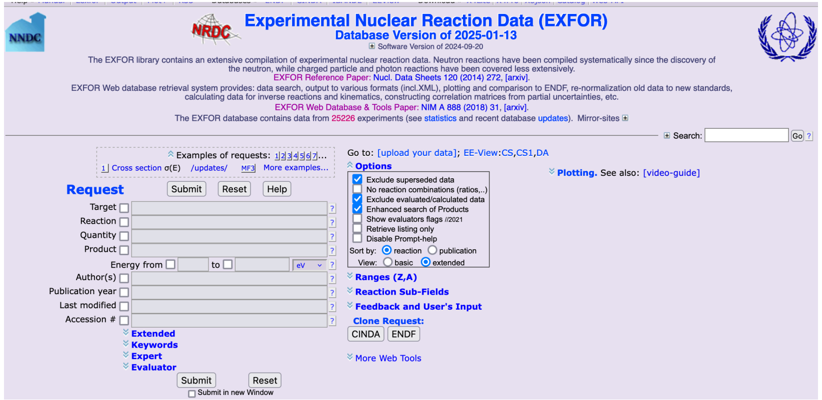
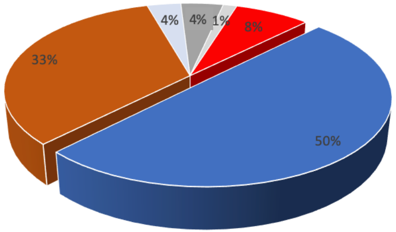
The EXFOR database is an awesome resource, but it only stores data as published not as USED FOR EVALUATIONS!

What we have:

- Easy access to 1,000s of data **as published**.
- Metadata describing the measurements and informing evaluators where information is otherwise hard to get.



EXFOR Data Point Contributions Worldwide



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<u>What we have:</u>

- Easy access to 1,000s of data **as published**.
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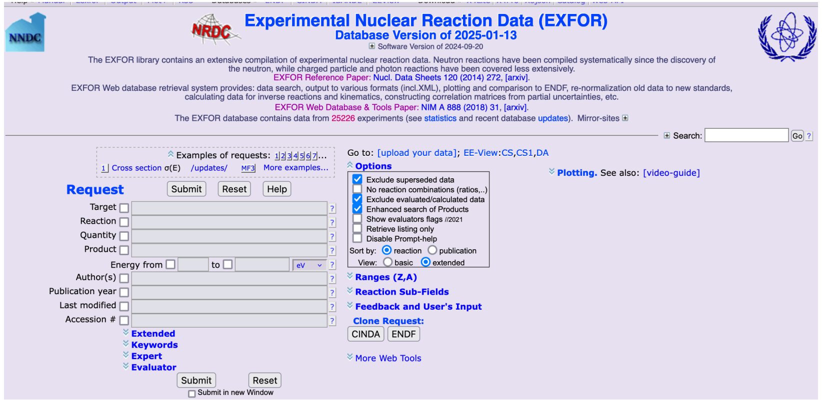
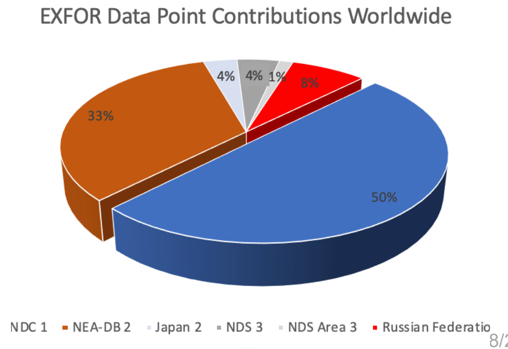
<u>What we need:</u>

- Permanent and open-access storage of experimental databases ***as used for evaluations to guarantee reproducibility.****
- Documentation of issues in past data.

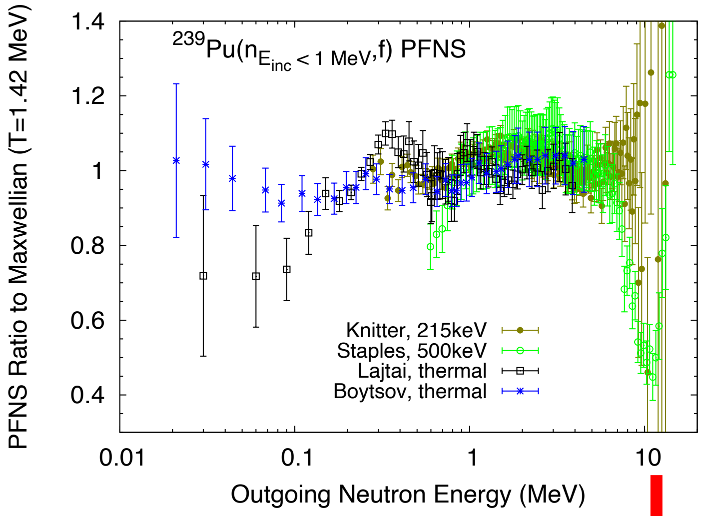




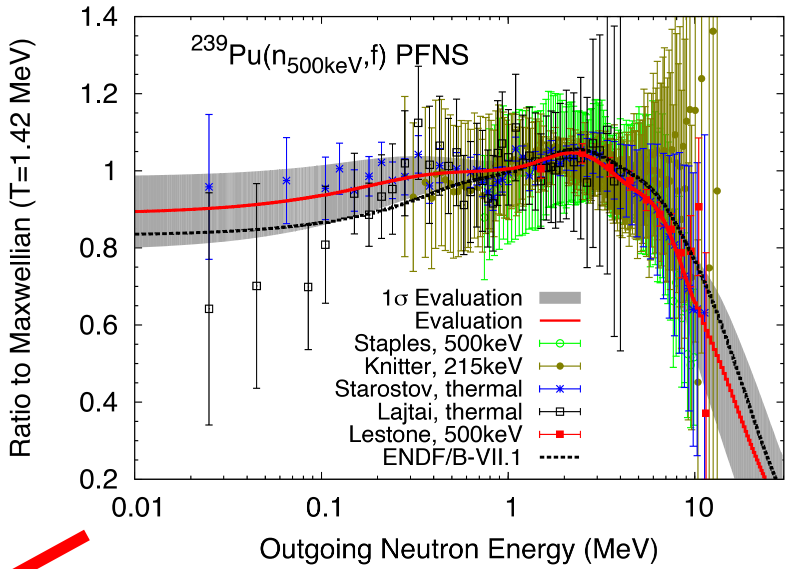
*see aims of NEA WPEC SG-54.

Significant impacts on evaluated data & application bounds if data straight from EXFOR or evaluator database is used.

Data straight from EXFOR



After detailed uncertainty estimate



Change in Jezebel k_{eff} 195 pcm!!! (2/3rd of difference between delayed and prompt critical)

Jezebel PFNS k_{eff} unc. drop by -69%!!!

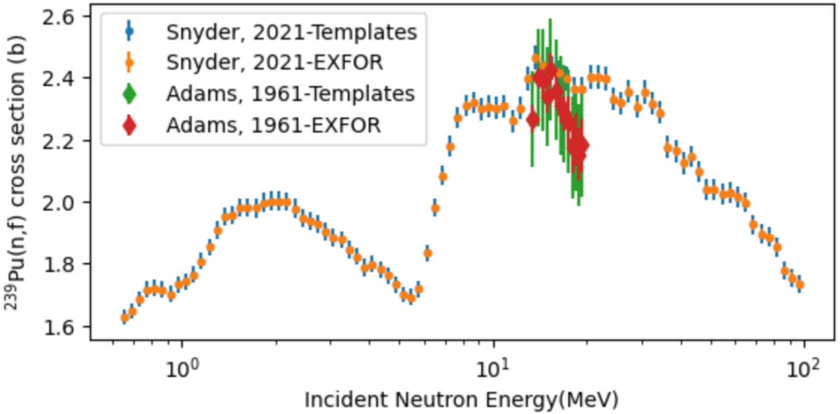
EXFOR is great but data should not be blindly adopted!

CSEWG templates of expected measurement uncertainties help to complete experimental unc. but are not enforced.

<u>What we have:</u>

- Templates for various ND measurements.
- Help experimenters as check-list to give complete info. & unc. for evaluation.
- Helps evaluator identify missing exp. unc. & gives values for their estimation + cor.

General introduction	D. Neudecker et al., EPJ N 9, 35 (2023) , https://doi.org/10.1051/epjn/2023014
Fission cross section	D. Neudecker et al., NDS 163, 228 (2020), https://doi.org/10.1016/j.nds.2019.12.005
Total cross section	A. Lewis et al., EPJ N 9, 34 (2023) , **https://doi.org/10.1051/epjn/2023018**
Capture and charged particle cross section	A. Lewis et al., EPJ N 9, 33 (2023) , **https://doi.org/10.1051/epjn/2023015**
Scattering cross section	J. Vanhoy et al., EPJ N 9, 31 (2023) , **https://doi.org/10.1051/epjn/2023019**
Neutron multiplicity	D. Neudeckeret al., EPJ N 9, 30 (2023) , **https://doi.org/10.1051/epjn/2023016**
Prompt fission neutron spectrum	D. Neudecker et al., EPJ N 9, 32 (2023) , **https://doi.org/10.1051/epjn/2023013**
Fission yields	E. Matthews, *Advancements in the nuclear data of fission yields*, PhD thesis, Department of Nucl. Engineering, University of California, Berkeley, USA, 2021.



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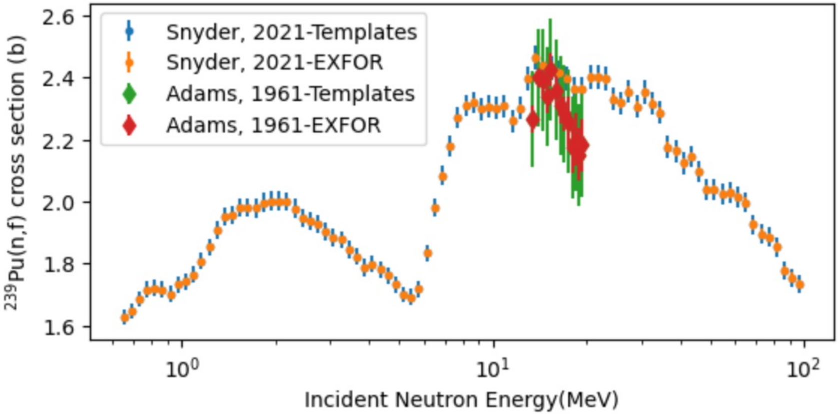
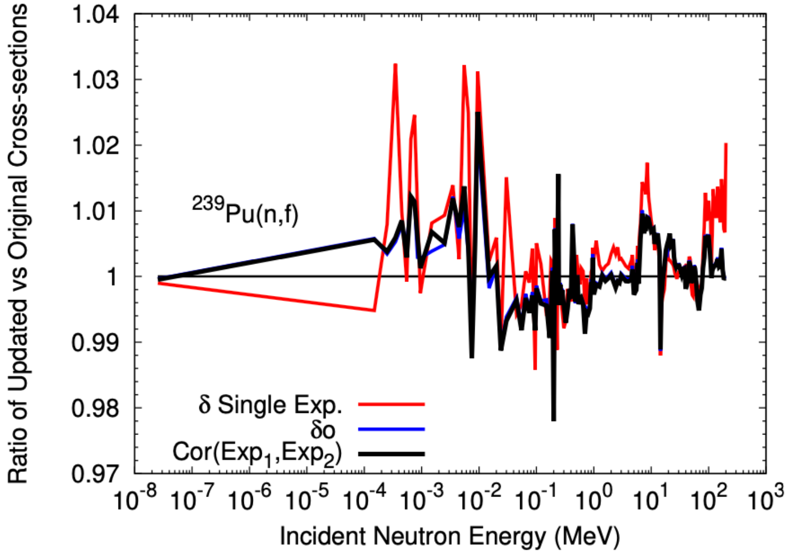
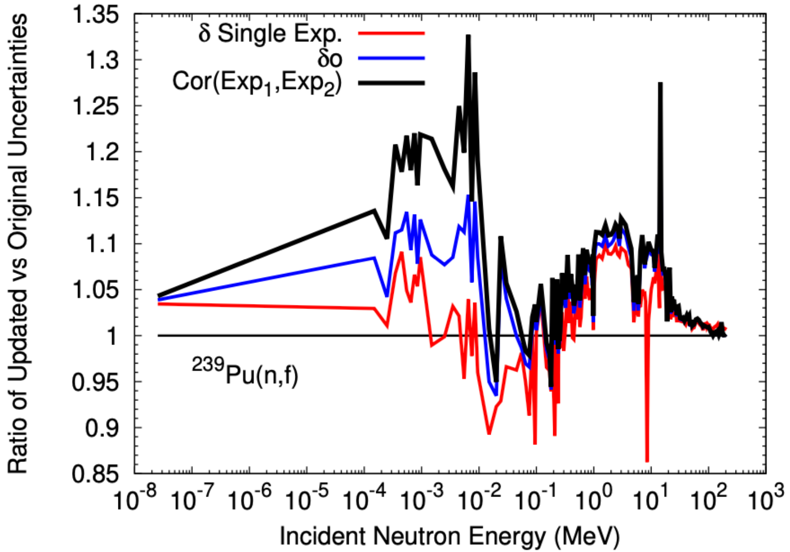
What we need: Encourage using templates
- EXFOR back-end programs for automatic inclusion of template unc.,
- EXFOR compilers to ask for missing information, and
- Journals to use it during review to improve quality of exp. unc.



Impact example: Including template uncertainties for Neutron Data Standards increased eval. Unc. by 30%!!





If we include additional uncertainties by templates, we get differences in evaluated 239Pu(n,f) cs by up to 2.5% and 30% increase in uncertainties.

→ Considering missing exp. unc. via templates does matter, so let's use them!

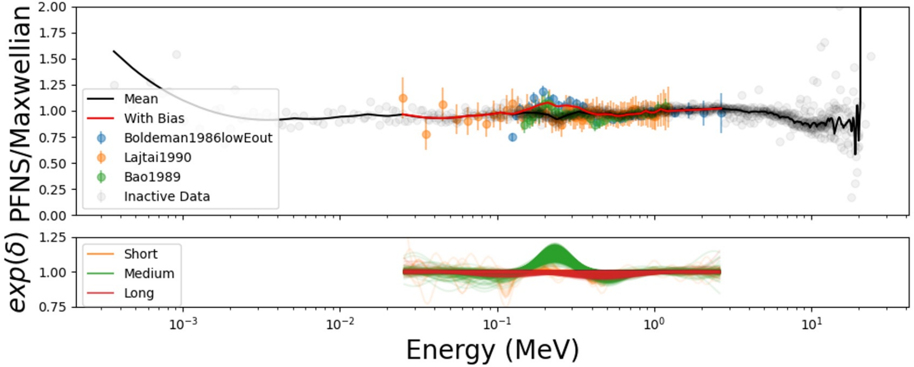
Bonus step for future use of ML: It would be important to have metadata in an automatically readable format.

<u>What we have:</u>

- Metadata in EXFOR as described in journal article.
- AI/ ML work that uses features to identify unknown issues in data driving systematic discrepancies leading to more realistic evaluated nuclear data.

	Correction Features	Hardware Features	Method Features
0	ShadowBarBackground	FissionDetector1_raw	RandomCoincidence
1	BackgroundCorrected	FissionDetector1_caseA	BackgroundGeneral
2	RandomCoincidenceBackground	FissionDetector1_caseB	BackgroundAlpha
3	GammaBackground	FissionDetector1_caseC	GammaBackground
4	AlphaBackground	FissionParticleDetected	MSinSample
5	WrapAroundBackground	FissionFragmentDetectorEfficiency	MSinSurrounding
6	MultipleScatteringSampleBackingCorrected	FissionDetectorGas_raw	FissionDetectorEfficiencyMethod
7	MultipleScatteringSurroundingCorrected	FissionDetectorGas_caseA	FFAbsorptionAngularDistributionMethod
8	AttenuationSampleBackingCorrected	AngularAcceptanceofFFDetector	NeturonDetectorResponseMethod
9	AttenuationSurroundingCorrected	NeutronDetector_raw	NeturonDetectorEfficiencyMethod
10	FissionDetectionEfficiencyCorrected	NeutronDetector_caseA	DeadtimeDeterminationMethod
11	NeutronDetectionEfficiencyCorrected	AngularCoverageofNeutronDetector	
12	NeutronDetectionResponseCorrected	NeutronDetectorSizeCM	
13	SampleDecayCorrected	NeutronDetectorStructuralMaterialAu	
14	FissionFragmentAbsorptioninSampleCorrected	NeutronDetectorStructuralMaterialAl	
15	SignalPulsePileupCorrected		
16	DeadtimeCorrected		
17	AngularDistributionFissionFragmentsCorrected		
18	ImpuritiesCorrected		

Neutron Detector: ^{6}Li AIACHNE



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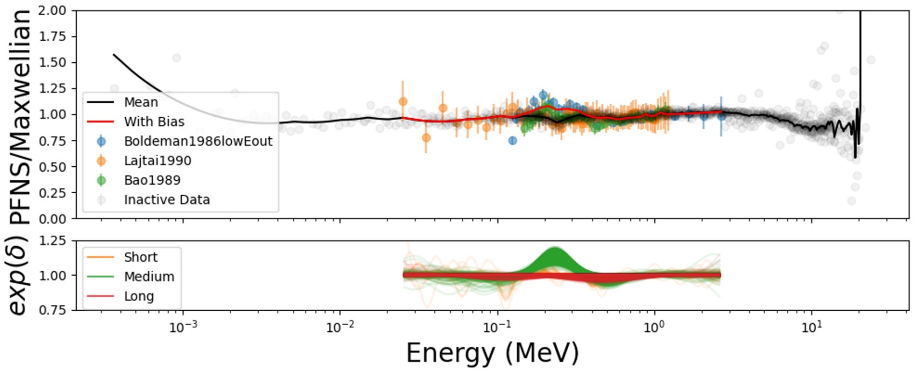
8	AttenuationSampleBackingCorrected	AngularAcceptanceofFFDetector	NeturonDetectorResponseMethod
9	AttenuationSurroundingCorrected	NeutronDetector_raw	NeturonDetectorEfficiencyMethod
10	FissionDetectionEfficiencyCorrected	NeutronDetector_caseA	DeadtimeDeterminationMethod
11	NeutronDetectionEfficiencyCorrected	AngularCoverageofNeutronDetector	
12	NeutronDetectionResponseCorrected	NeutronDetectorSizeCM	
13	SampleDecayCorrected	NeutronDetectorStructuralMaterialAu	
14	FissionFragmentAbsorptioninSampleCorrected	NeutronDetectorStructuralMaterialAl	
15	SignalPulsePileupCorrected		
16	DeadtimeCorrected		
17	AngularDistributionFissionFragmentsCorrected		
18	ImpuritiesCorrected		

Neutron Detector: ^{6}Li *AIACHNE*



<u>What we need:</u>

- All features in a consistent and automatically readable format.
- Open-source AI/ ML tools to use them.

Summary of needs:

- Permanent and open-access storage of experimental databases ***as used for evaluations to guarantee reproducibility.***
- Implementation of templates into automatic back-end program of EXFOR **to speed up evaluation process.**
- Encourage experimenters to supply uncertainty sources as listed in templates through journals and EXFOR compilation to **guarantee best of use of experimental data.**
- Store experimental metadata in automatically readable format **to enable AI/ML studies on quality of data.**

<u>Benefits:</u> better UQ giving better application calculations, faster evaluations, more reproducibility!