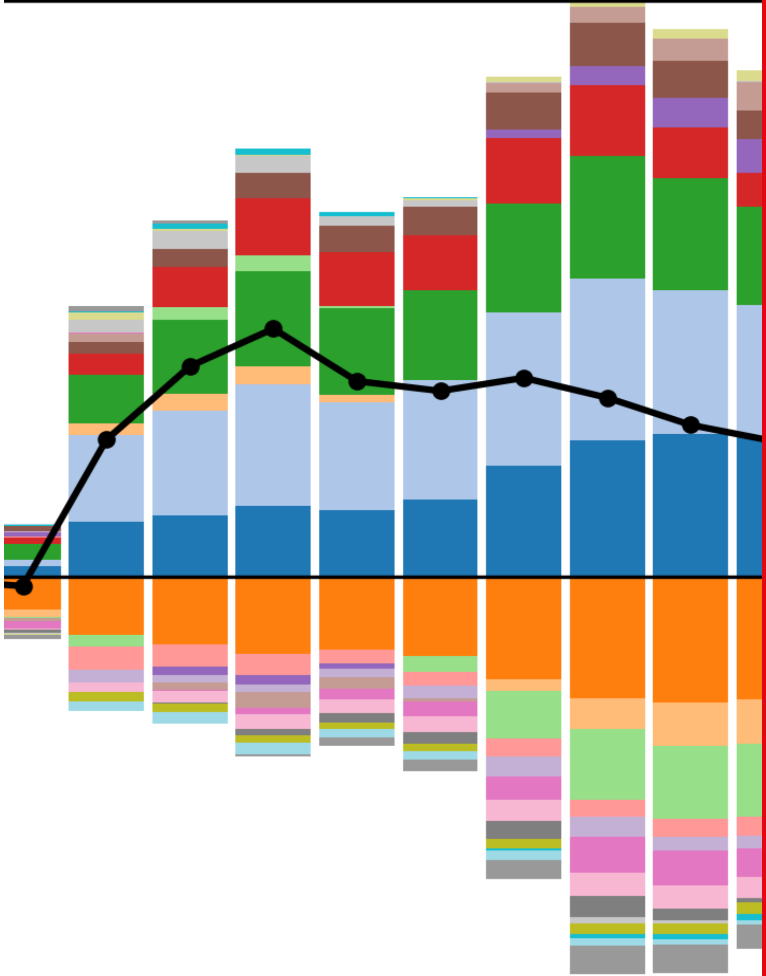


WONDER 2026

DARN: A tool for nuclear data roundtrip adjustment and its application to the NEA subgroup 52 exercise

Andry Monlon, Mathieu Hursin

30.06.2026

DARN

DARN: Data Assimilation Routine for Nuclear

Python library, modular data assimilation core based on [1]

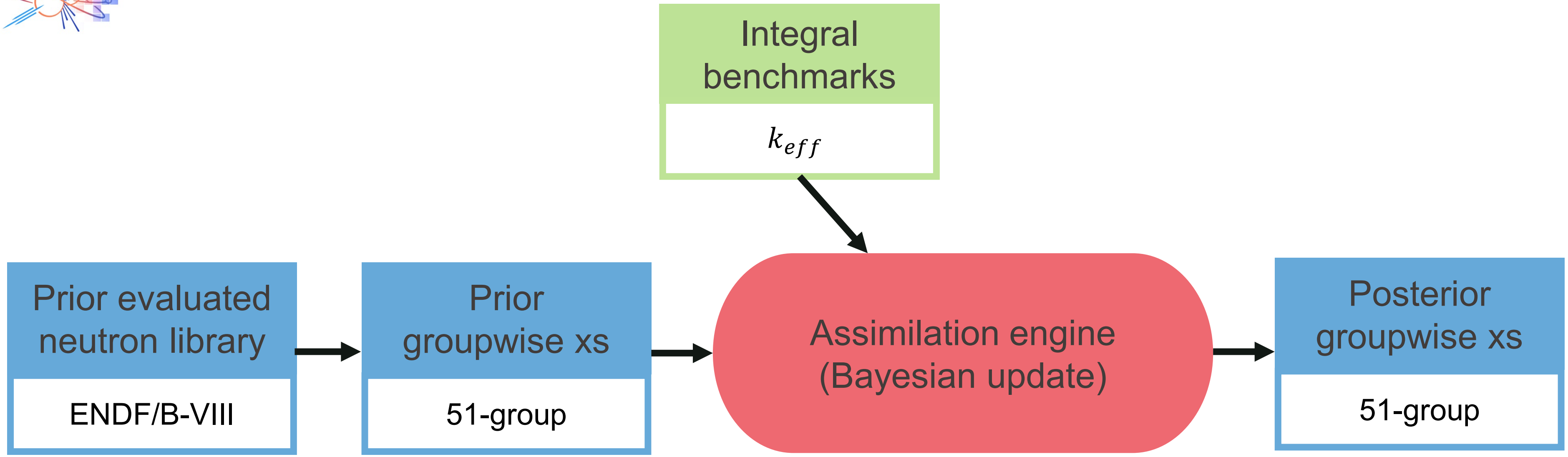
↳ Testing on NEA WPEC SG52 exercise “*Adjustment of the Pu-239 cross-sections in the **fast energy range***”

- demonstrate the possibility to reconstruct <u>in a transparent and automated way</u> a modern evaluation, starting from its previous version

- investigate where we can produce accurate nuclear data file(s) through the combined assimilation of differential and integral data”

[1] D. J. Siefman. Development and Application of Data Assimilation Methods in Reactor Physics (2019)

Data assimilation



Assimilation engine – GLLS

INPUT DATA

- Prior groupwise nuclear data $\sigma_g,\ M_{\sigma_g}$
- Integral experimental responses $E,\ M_E$
- Integral calculated responses $C,\ M_C = S^T M_{\sigma_g} S,\ \boldsymbol{S} = \boldsymbol{dC/d\sigma_g}$

METHOD | Generalized **Linearized** Least Square

Optimization of the Chi2 (cost function to minimize):

$$\chi^2(\sigma) = (\sigma - \sigma_0)^T M_\sigma^{-1}(\sigma - \sigma_0) + (E - C)^T (M_E + M_M)^{-1}(E - C)$$

GLLS UPDATE

Kalman gain

$$K = M_\sigma S^T (S M_\sigma S^T + M_E + M_M)^{-1}$$

Posterior nuclear data and covariance

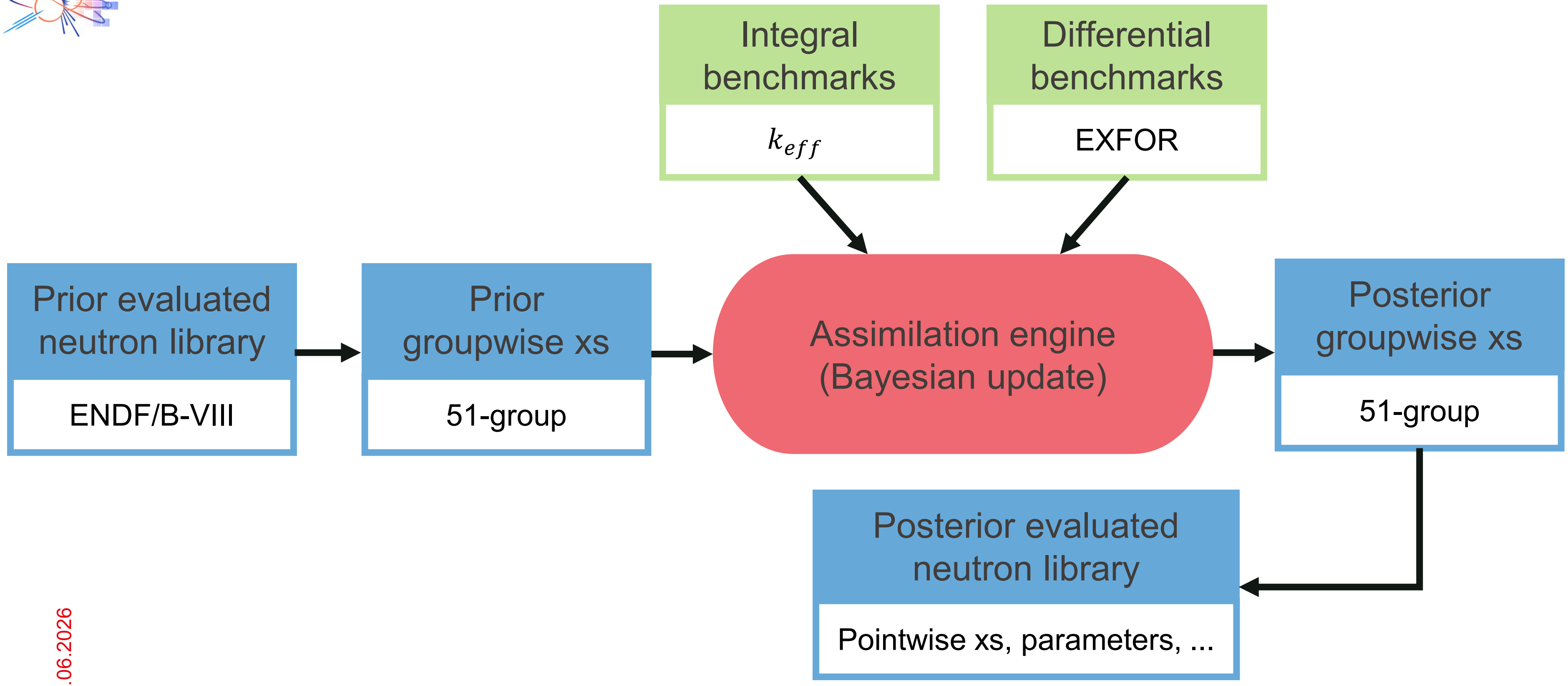
$$\sigma_{post} = \sigma_0 + K(E - C_{prior})$$

$$M_\sigma^{post} = M_\sigma - K S M_\sigma$$

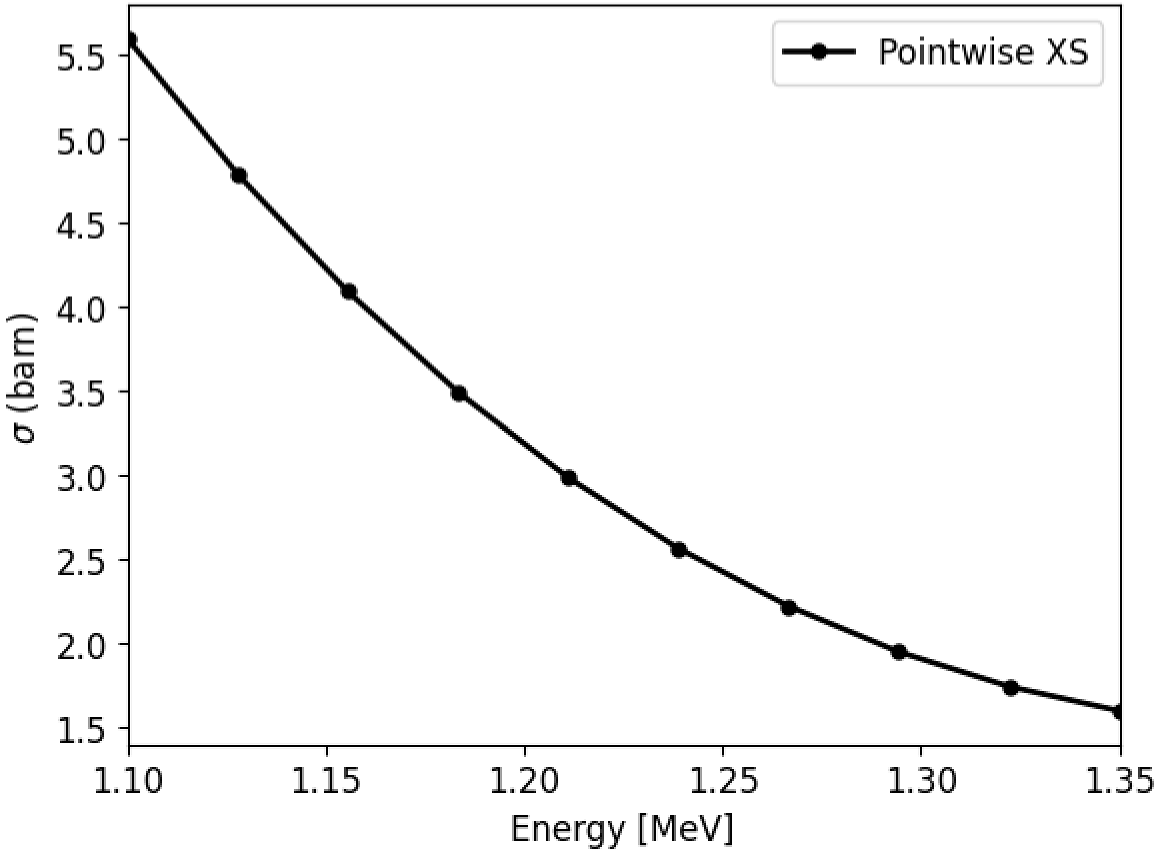
Posterior responses - no calculation re-run

$$C_{post} = C_{prior} + S(\sigma_{post} - \sigma_0)$$

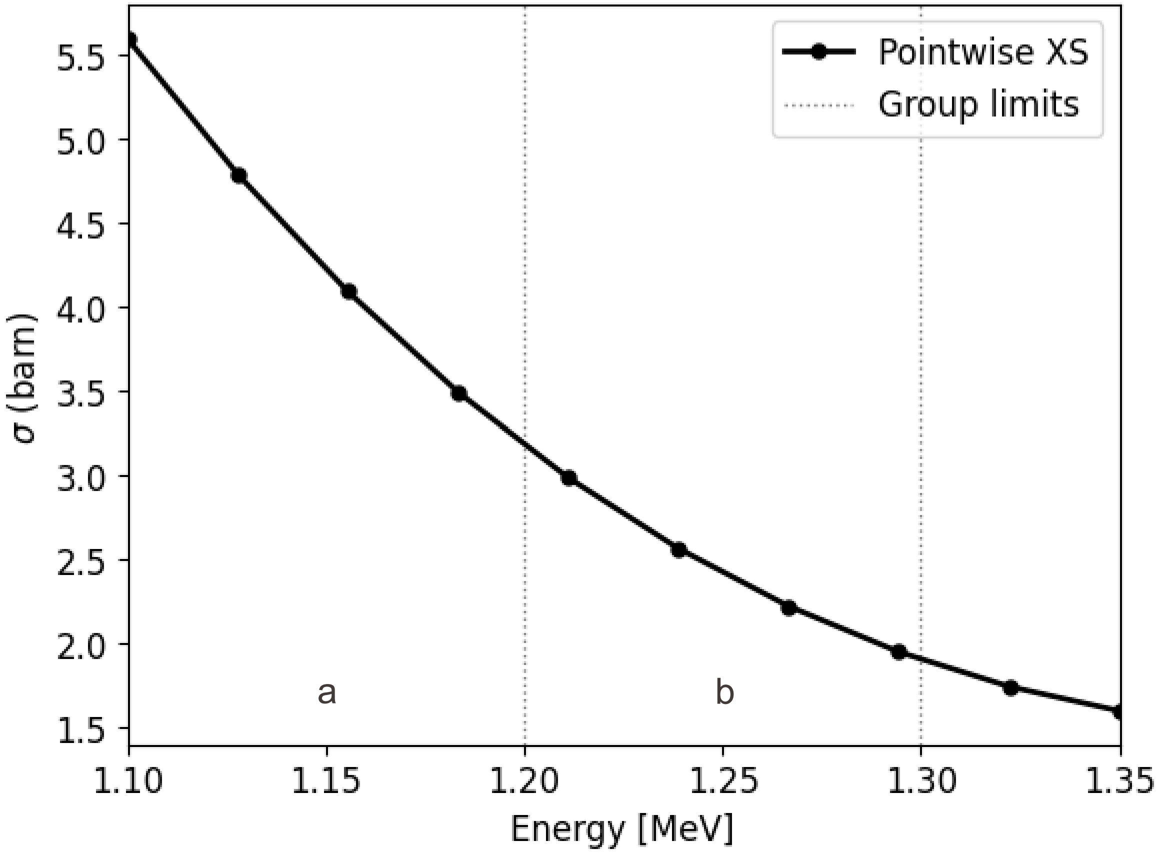
Data assimilation for evaluation



How to ingest differential data in fast range

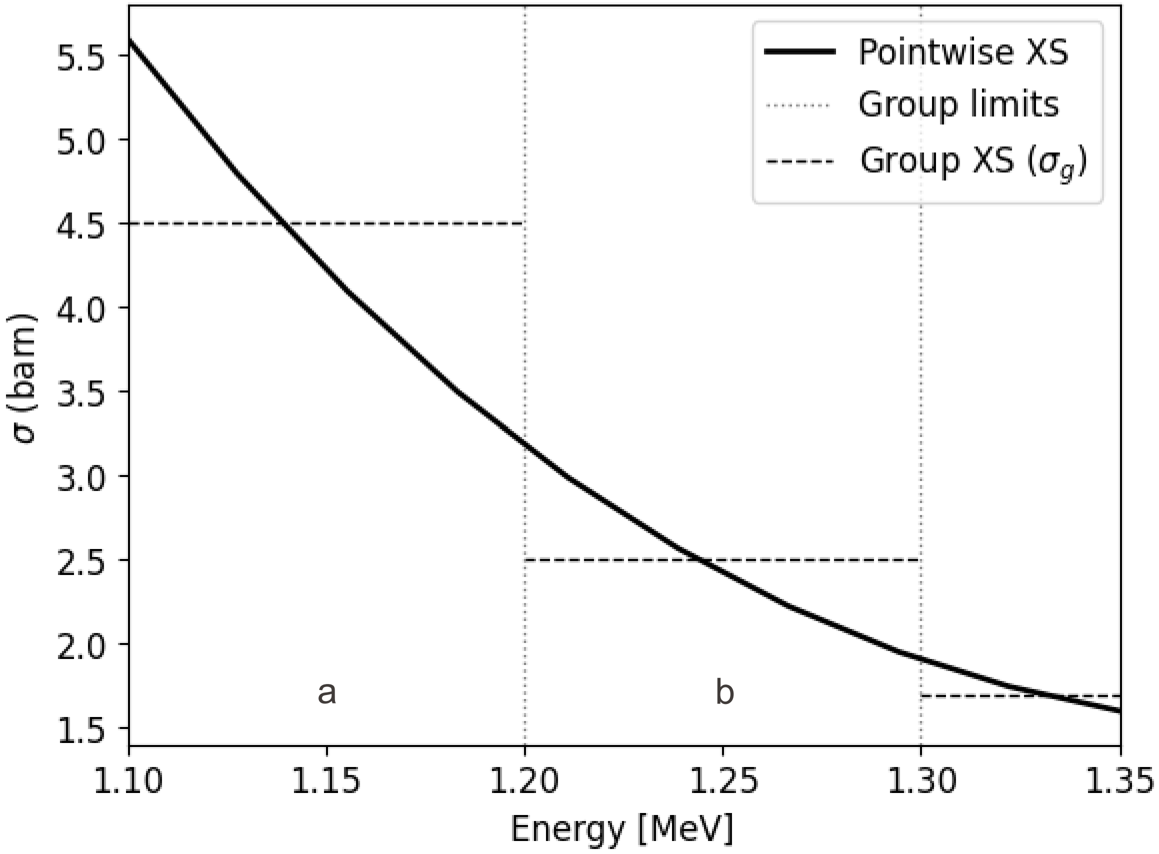


How to ingest differential data in fast range



How to ingest differential data in fast range

$$\sigma_g = \frac{\int \sigma\phi dE}{\int \phi dE}$$

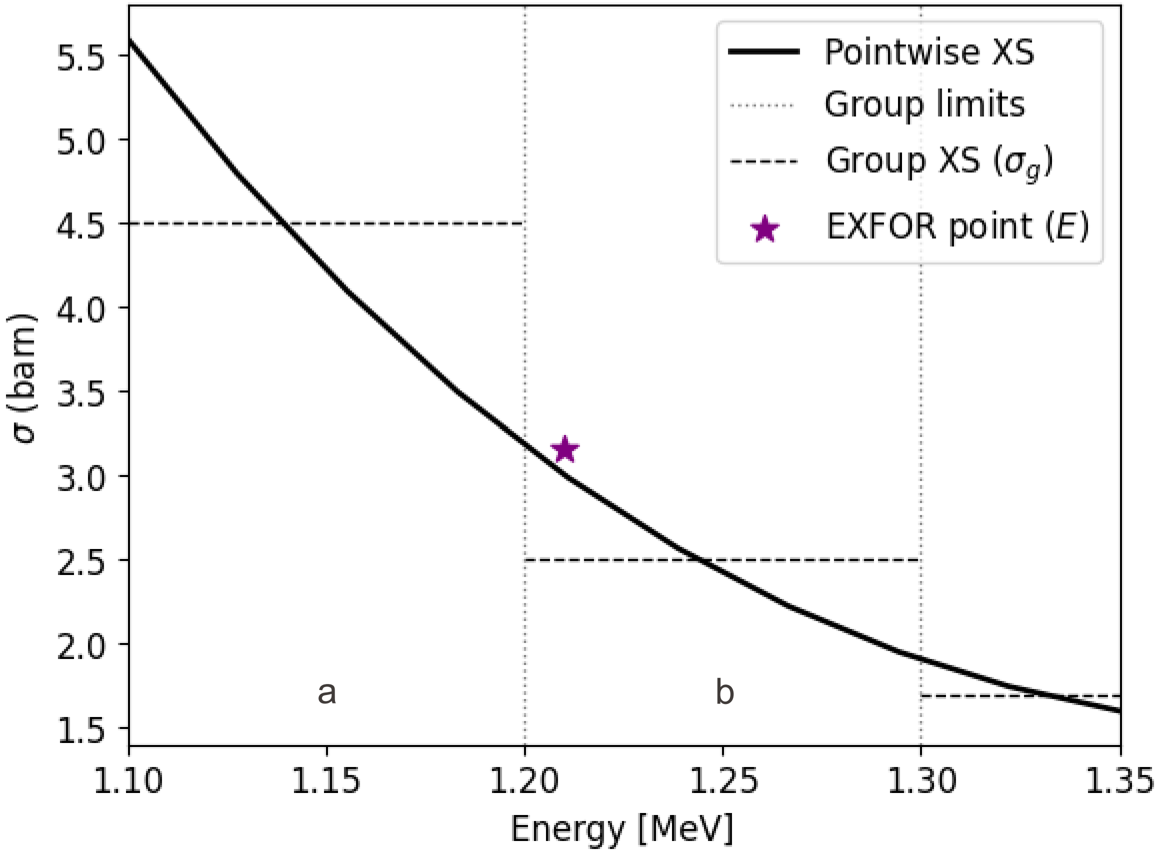


How to ingest differential data in fast range

$$\sigma_g = \frac{\int \sigma \phi dE}{\int \phi dE}$$

$$d = E - \boldsymbol{C}$$

$$M_C = \boldsymbol{S}^T M_{\sigma_g} \boldsymbol{S}$$



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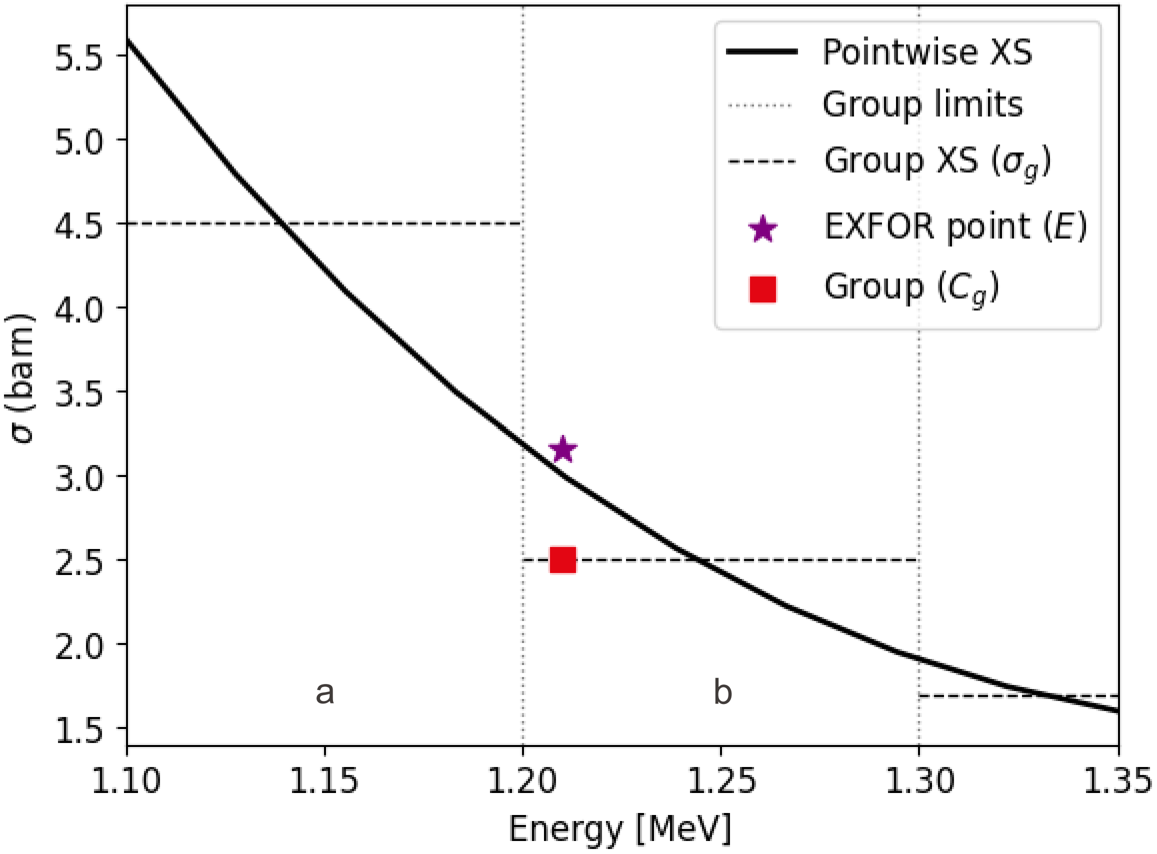

$$C_g = \sigma_g$$

$$\frac{dC_g}{d_{\sigma_{gb}}} = 1$$

How to ingest differential data in fast range

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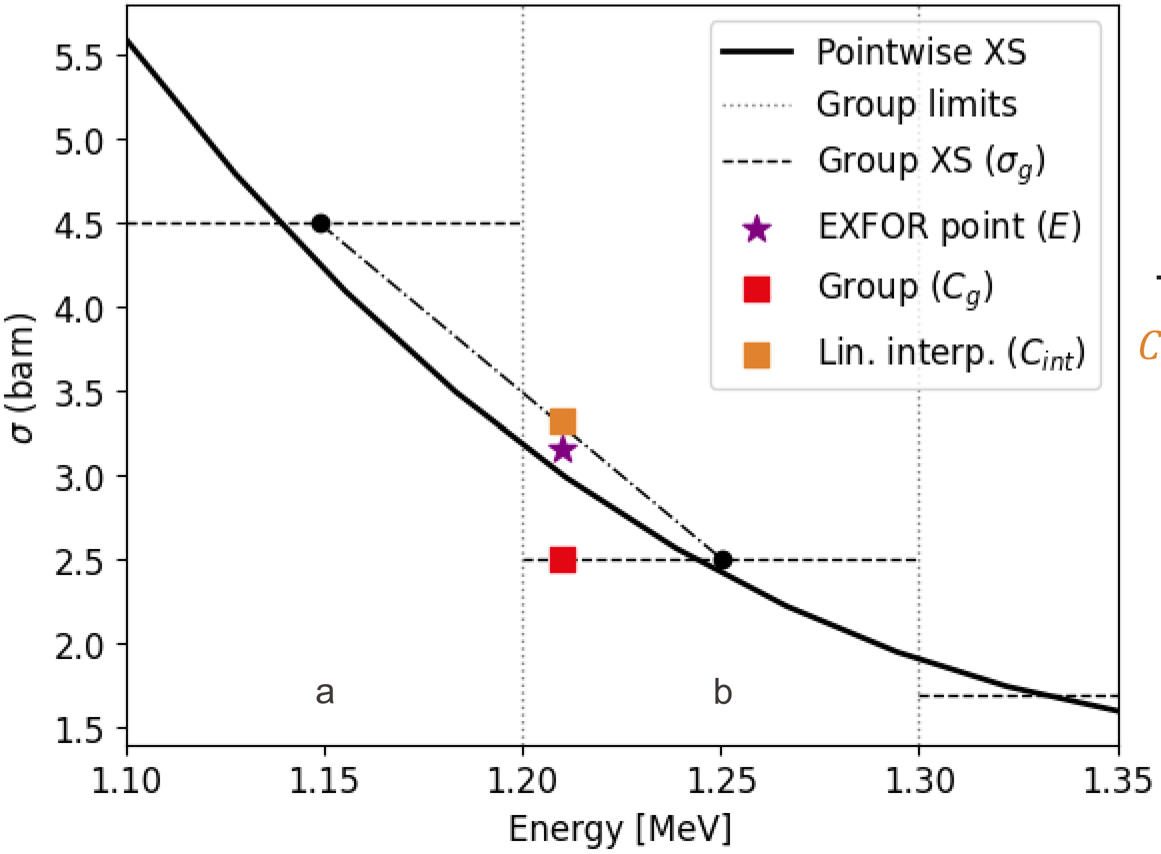


$$C_g = \sigma_g$$

$$\frac{dC_g}{d_{\sigma_{gb}}} = 1$$

$$C_{int} = \sigma_g^a w_a + \sigma_g^b w_b$$

$$\frac{dC_{int}}{d_{\sigma_g}} = \begin{pmatrix} w_a \\ w_b \end{pmatrix}$$

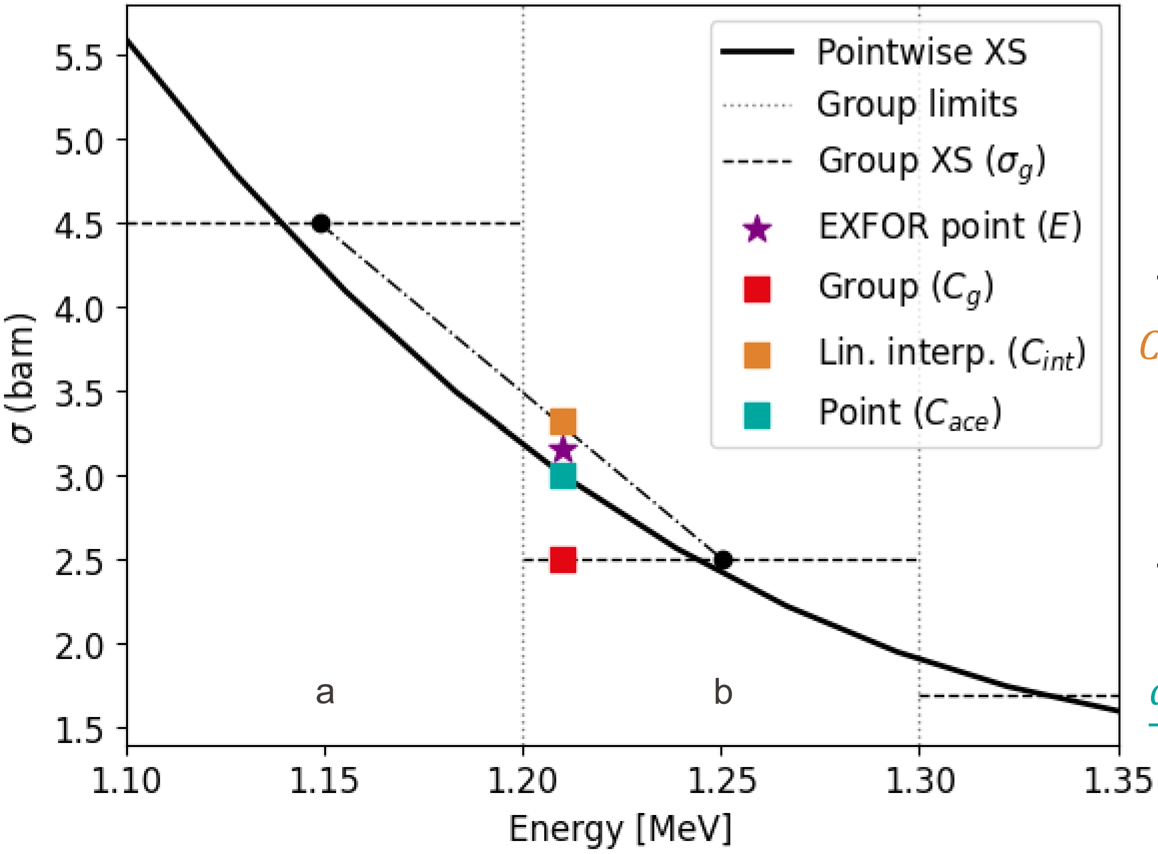
EPFL

How to ingest differential data in fast range

$$\sigma_g = \frac{\int \sigma\phi dE}{\int \phi dE}$$

$$d = E - \boldsymbol{C}$$

$$M_C = \boldsymbol{S}^T M_{\sigma_g} \boldsymbol{S}$$



$$C_g = \sigma_g$$

$$\frac{dC_g}{d_{\sigma_{gb}}} = 1$$

$$C_{int} = \sigma_g^a w_a + \sigma_g^b w_b$$

$$\frac{dC_{int}}{d_{\sigma_g}} = \begin{pmatrix} w_a \\ w_b \end{pmatrix}$$

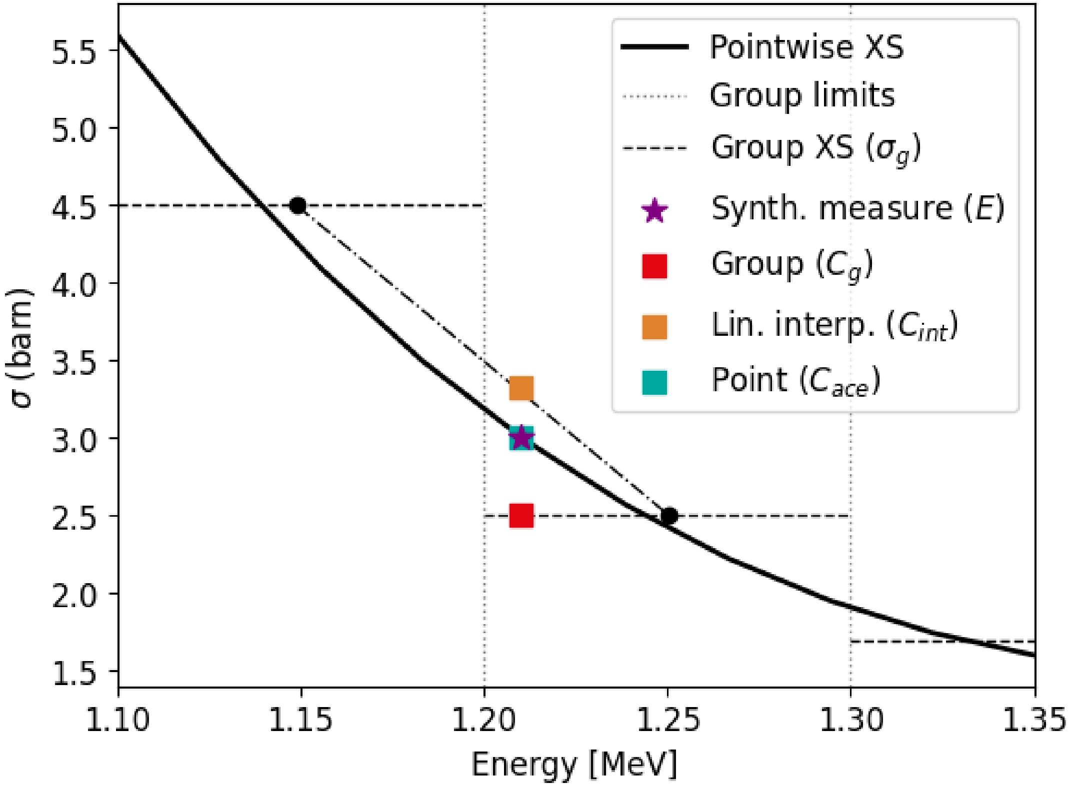
$$C_{ace} = \sigma_{ace}$$

$$\frac{dC_{ace}}{d_{\sigma_g}} = \frac{dC_{ace}}{d\sigma_{ace}} \frac{d\sigma_{ace}}{d\sigma_g} = 1 \times \frac{d\sigma_{ace}}{d\sigma_g}$$

A null test: when the data is the prior, who updates?

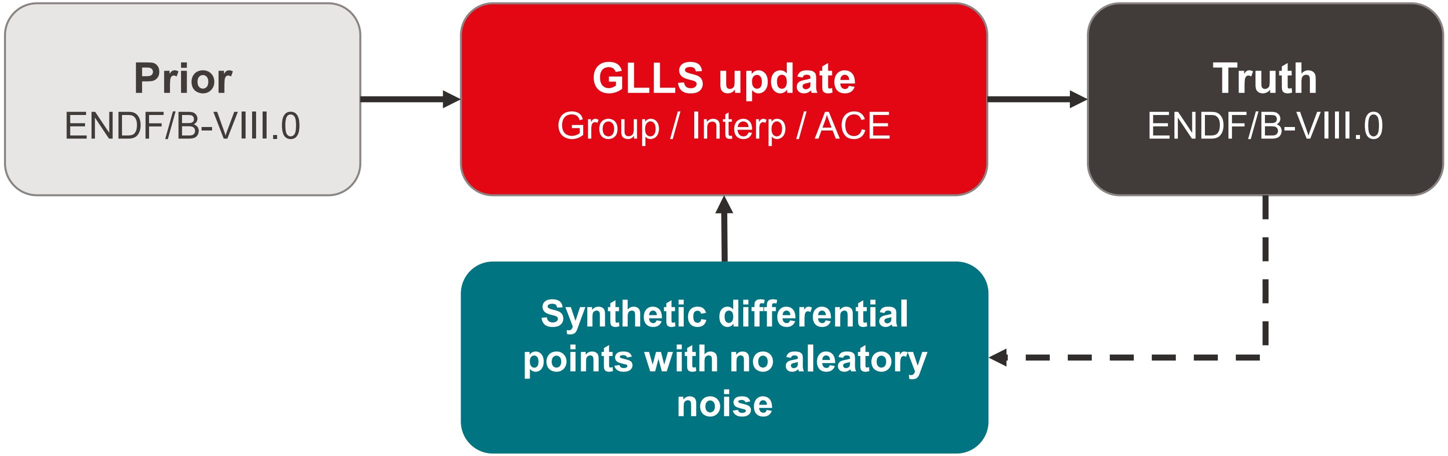
Sample noise-free EXFOR points from the prior evaluation itself. A "correct" assimilation must not move the posterior.

$$d = E - C$$



A null test: when the data is the prior

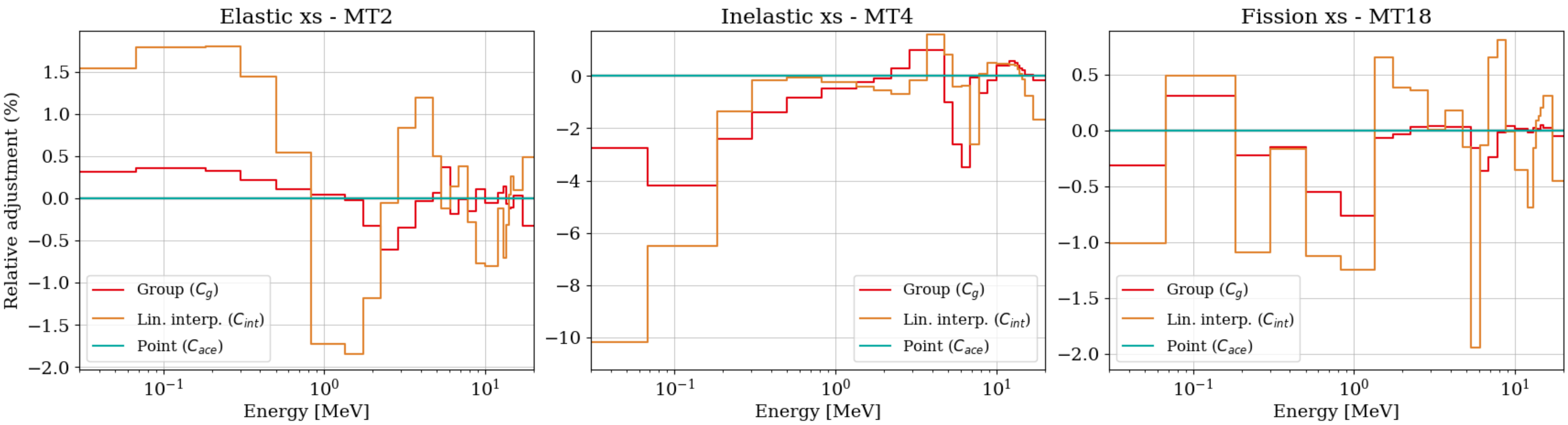
GLLS run with only differential responses, no integral one



Synthetic differential points: 2000 points per reaction on a log-uniform grid from 30 keV to 20 MeV
ENDF/B-VIII.0 Pu-239 ACE file using a flat flux
Constant experimental uncertainty assumed at 0.5 %

A null test: when the data is the prior, who updates?

MT2 + MT4 + MT18

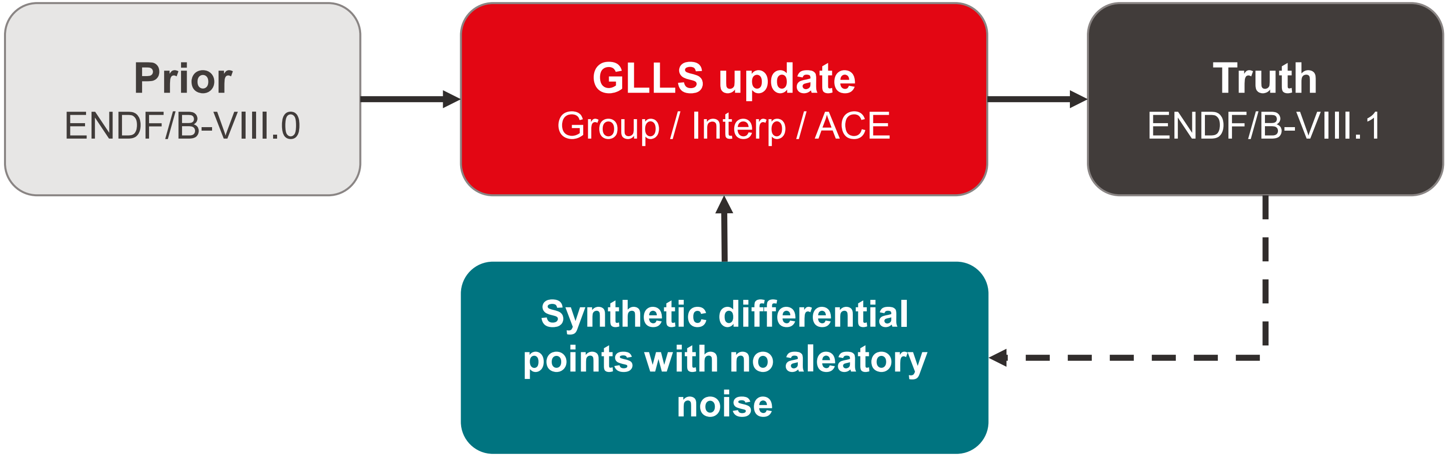


➡ For the three cross-sections, the point (ACE) is the only unbiased approach

➡ Linear interpolation does not clearly improve compared to direct group value use

Test case: from ENDF/B-VIII.0 to .1

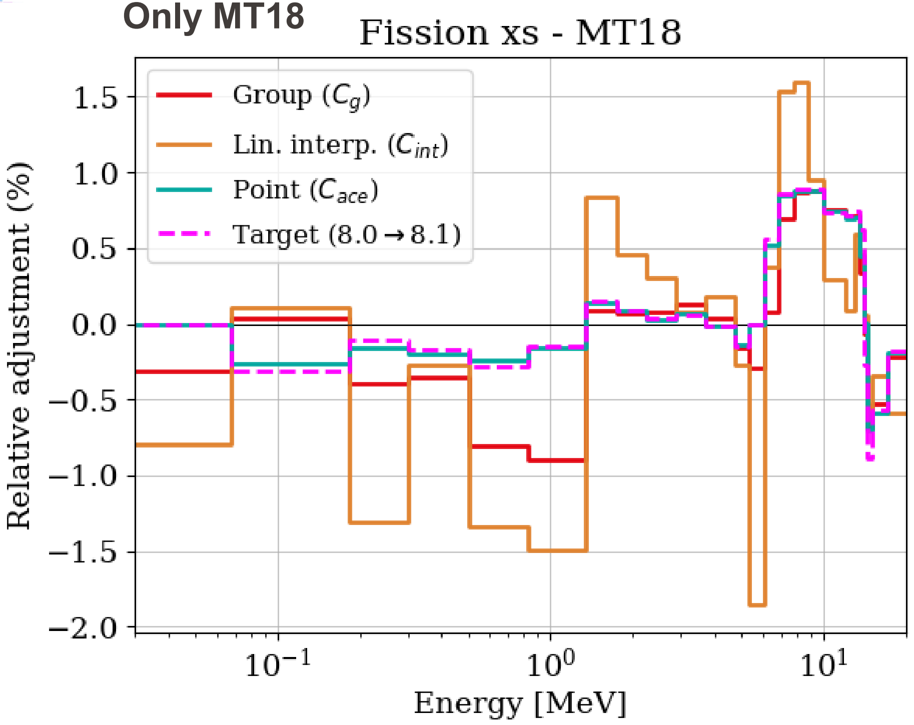
GLLS run with only differential responses, no integral one

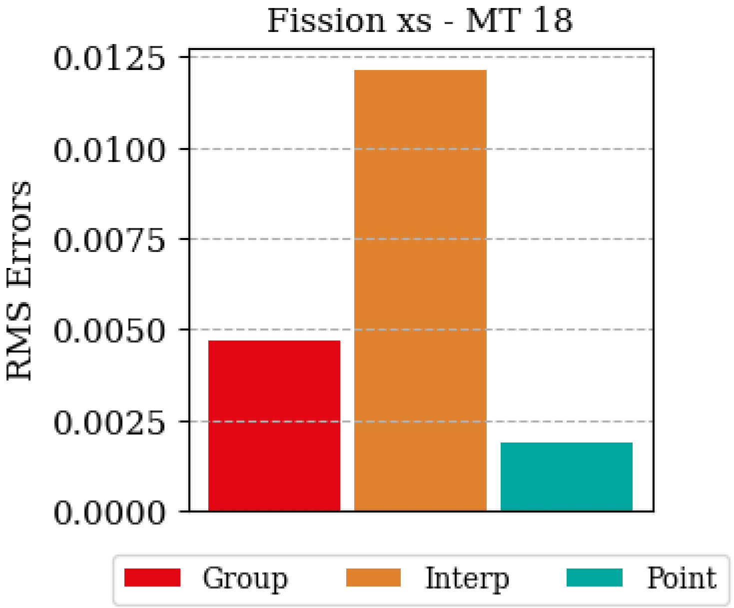


Synthetic differential points: 1000 points per reaction on a log-uniform grid from 30 keV to 20 MeV
ENDF/B-VIII.1 Pu-239 ACE file using a flat flux
Constant error assumed at 0.5 %

Test case: from ENDF/B-VIII.0 to .1

Only MT18

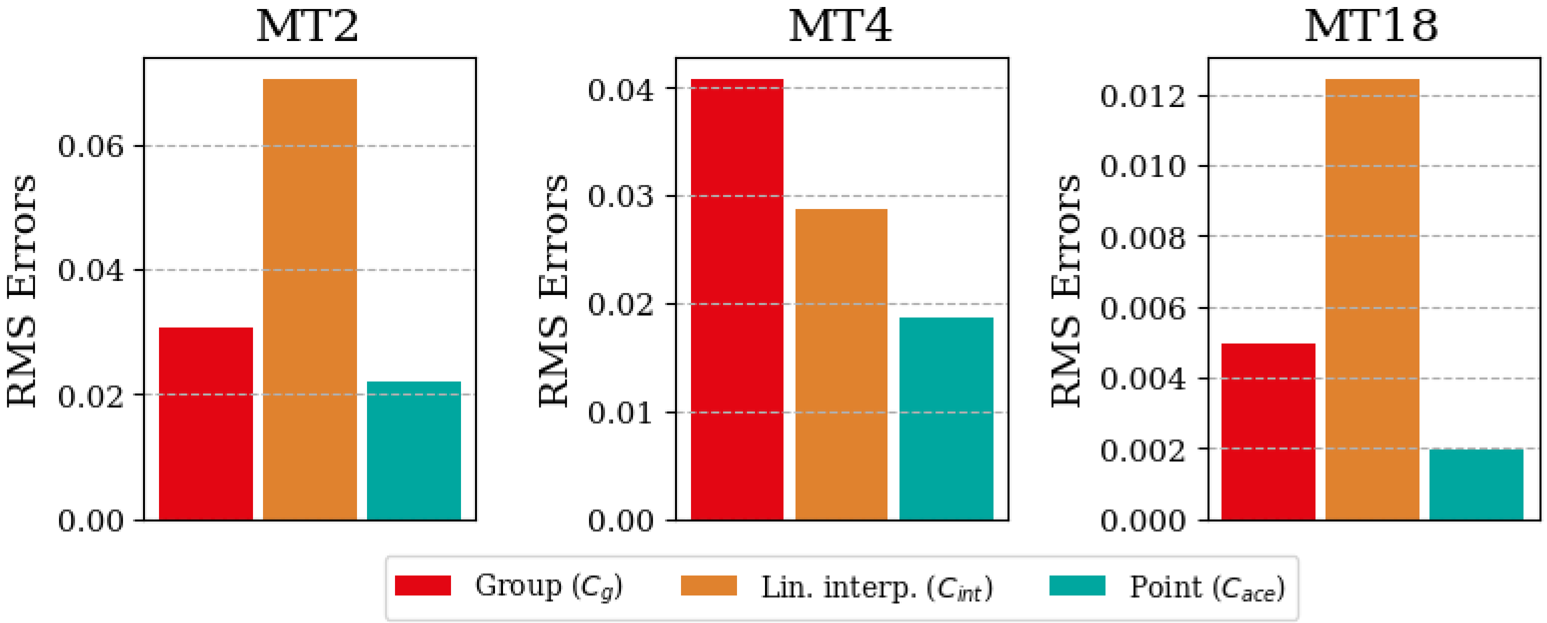




- The point (ACE) approach decreases the RMS error between the adjusted xs and the target ENDF/B-VIII.1
- Works as well for MT2 and MT4 separately

Test case: from ENDF/B-VIII.0 to .1

MT2 + MT4 + MT18

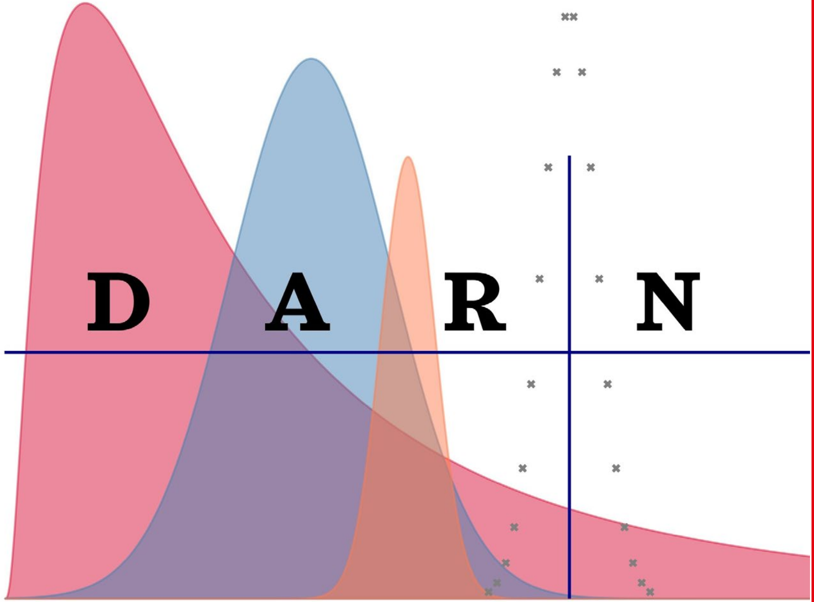


Conclusion

- To include differential nuclear data in the data assimilation groupwise framework, 3 techniques were proposed and compared
- The simple linear interpolation method which can intuitively seem better is not improving the results
- Adding the pointwise values to the assimilation framework is justified. It performs better and it is unbiased on a null assimilation
- Currently being tested on SG52 exercise data (XS, PFNS, nubar)

JEZEBEL	ICSBEP PMF-001
EUCLID 3x2	LANL
EUCLID 1x8	LANL
Marini neutron multiplicity	EXFOR entry 14799002
Marini PFNS	EXFOR entry 14684002
Snyder	EXFOR entry 14721002
Dongwi	EXFOR entry 14851002
SACS-Cf	Table 11 of [2]

[2] R. Capote, G. Schnabel, A. D. Carlson, V. G. Pronyaev, G. Noguere, and D. Neudecker, “Experimental spectrum averaged cross sections (SACS) in 252 Cf(sf) neutron field and its impact on the evaluation of neutron standards,” *EPJ Web Conf.*, vol. 281, p. 00027, 2023, doi: 10.1051/epjconf/202328100027.



Thank you for listening

Questions ?

Andry Monlon, Mathieu Hursin

EXFOR data insertion into GLLS

Group

$$C = \sigma_g$$

$$\frac{dC_g}{d_{\sigma_g}} = 1$$

C = group average value

H = one-hot sensitivity (group attribution)

No within-group shape

Interp

$$C_{int} = \sigma_g^a w_a + \sigma_g^b w_b$$

$$\frac{dC_{int}}{d_{\sigma_g}} = \begin{pmatrix} w_a \\ w_b \end{pmatrix}$$

$$\tilde{E}_g = \sqrt{E_g \, E_{g+1}}$$

C = Interpolation between group nodes geometric midpoint

The sensitivities capture the inter-group slope

Point

$$C_{ace} = \sigma_{ace}$$

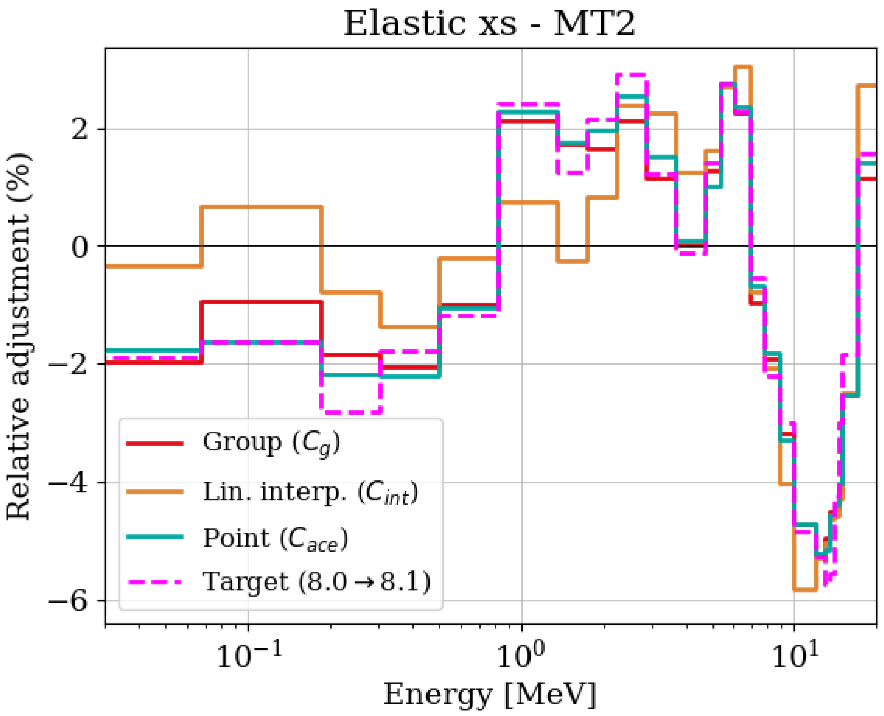
$$\frac{dC_{ace}}{d_{\sigma_g}} = \frac{dC_{ace}}{d\sigma_{ace}} \frac{d\sigma_{ace}}{d\sigma_g}$$

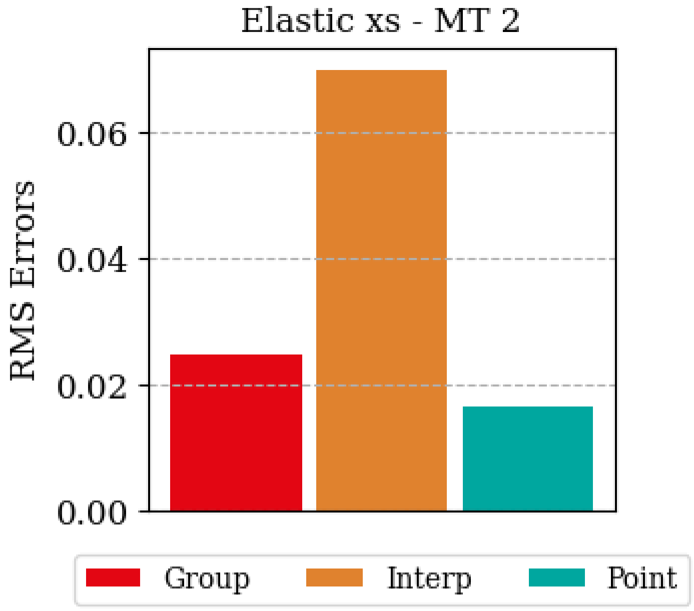
$$= 1 \times \frac{d\sigma_{ace}}{d\sigma_g}$$

$$= \frac{\sigma_{ace}(E)}{\sigma_g}$$

Test case: from ENDF/B-VIII.0 to .1

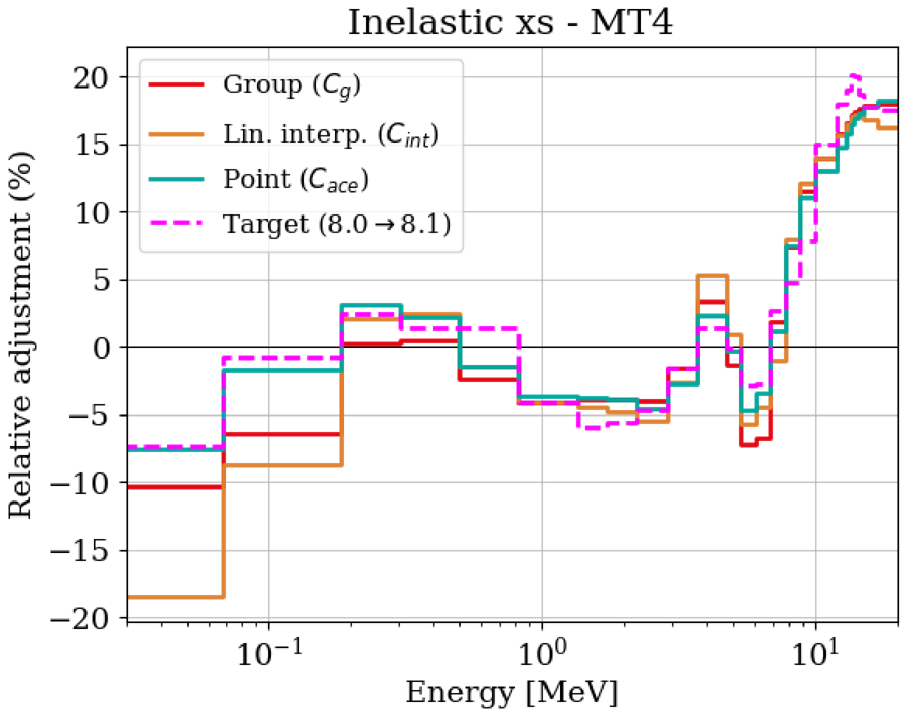
Only MT2

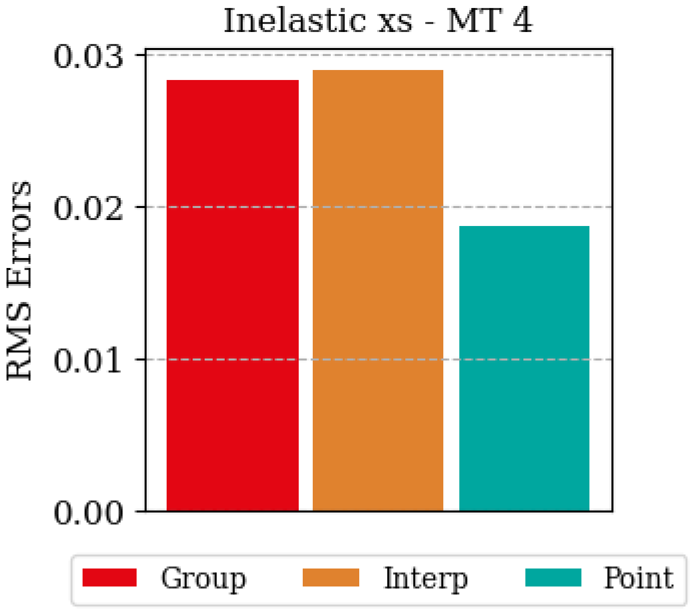




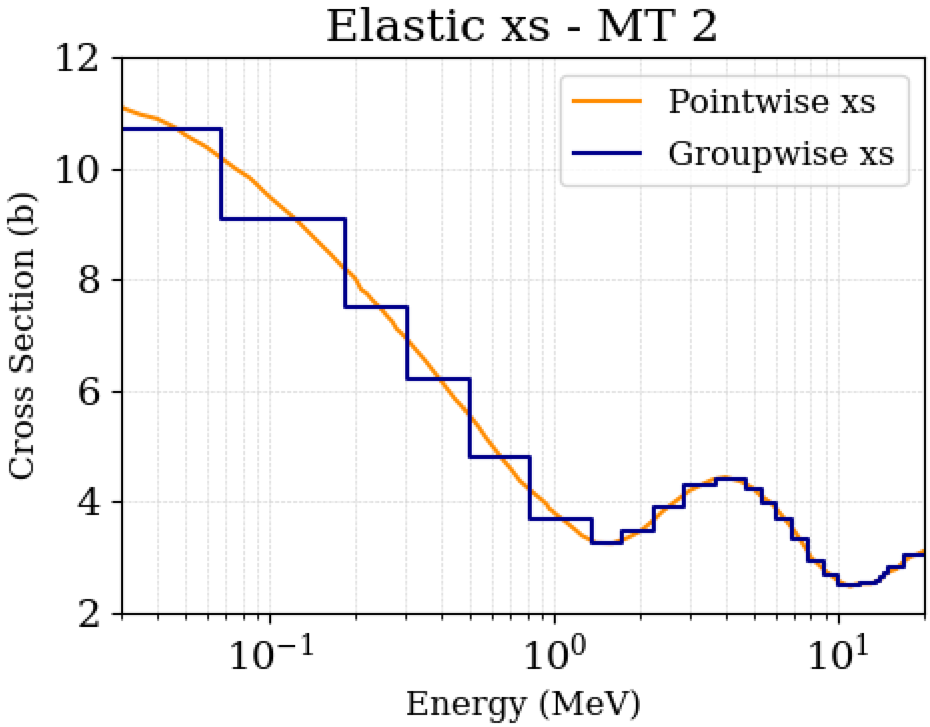
Test case: from ENDF/B-VIII.0 to .1

Only MT4





ENDF/B-VIII.1 - pointwise and groupwise xs in fast range



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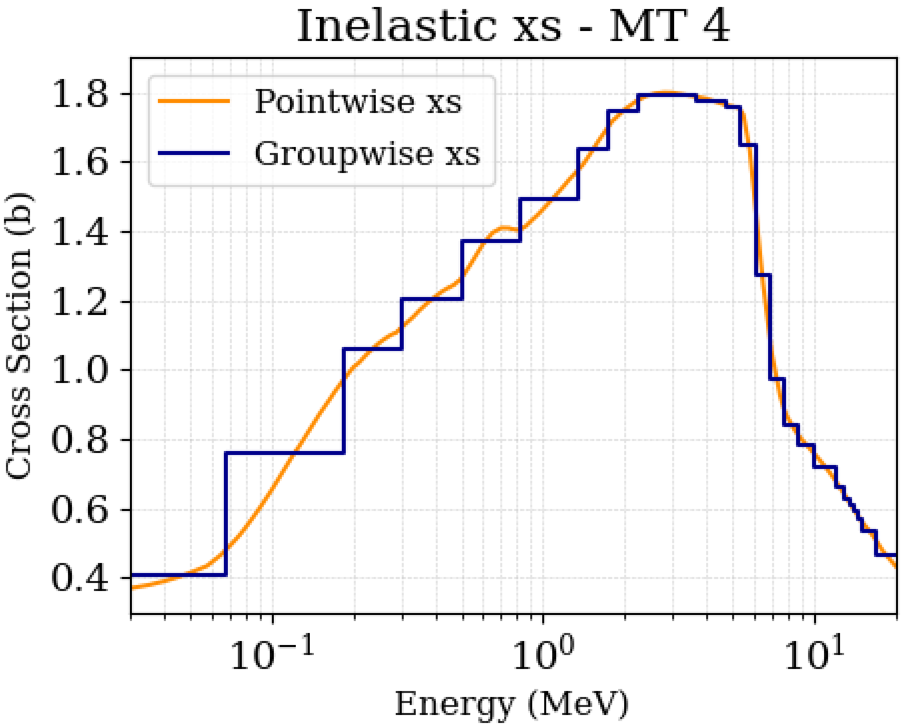

ENDF/B-VIII.1 - pointwise and groupwise xs in fast range