Los Alamos NATIONAL LABORATORY

Introduction to covariance session and covariance testing

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Thanks to: Nathan Gibson + template team!

We are in the home-stretch of ENDF/B-VIII.1. Let's make sure we have great covariances!

Updates from the covariance session:

- Many covariances were released as part of VIII.1 beta libraries. ***Thank you!!!***
- Testing is ongoing. ***Thank you!!!***
- ***Please***, to make this a great library for covariances, fix issues found!

Other:

- **6 out of 7 template papers published as special issue in EPJ-N!**
  - **https://www.epj-n.org/component/toc/?task=topic&id=1953**
- Report on UQ needs for the next 5-10 years coming out soon.

These covariances changed from VIII.1beta1 -> beta2:

- Light elements: 001-H-001/002, 003-Li-006/007, 005-B-010
- 011-Na-023, 012-Mg-024, 013-Al-027, 014-Si-029, 015-P-031, 016-S-032, 019-K-039, 019-K-041, 023-V-051, 025-Mn-055, 033-As-075, 036-Kr-086, 036-Kr-086, 039-Y-089, 040-Zr-090, 044-Ru-102, 045-Rh-103, 053-I-127, 054-Xe-132, 58-Ce-140/ 142, 059-Pr-141, 060-Nd-143, 061-Pm-147, 063-Eu-155, 064-Gd-152/160, 069-Tm-169/ 170, 079-Au-197, -Bi-209
- 022-Ti: 046, 047, 048,
- 026-Fe-054, 027-Co-059, 028-Ni-058, 028-Ni-060
- 030-Zn: 064, 067, 068
- 042-Mo: 092, 097, 098, 100
- 066-Dy: 156, 158, 160, 161, 162, 163, 164
- 082-Pb: 204, 206-208
- Actinides: 092-U-233/ 235, 094-Pu-239/ 240

List from Nathan Gibson.

How did we get and test the covariances?

- Nathan Gibson processed MF=31,32,33 with NJOY2016,
- They were processed onto a LANL-defined 51-energy grid, and put into json file.

- They were tested via Denise Neudecker's ``CovVal'' code for:
    - Maths properties: positive semi-definite, symmetry, |cor| <=1
    - Physics properties: checking if relative uncertainties are within
        - Expert judgment limits by Don Smith,
        - Template limits,
        - Standards limit,
        - PUBs (fission only).

CovVal testing is documented in Neudecker, "Definitions on Testing Whether Evaluated Nuclear Data Relative Uncertainties are Realistic in Size", LA-UR-21-32171 (2021).

Comment: I also have that for all ENDF/B-VIII.0 covariances if there is interest.

Mathematical checks performed:

Passed all

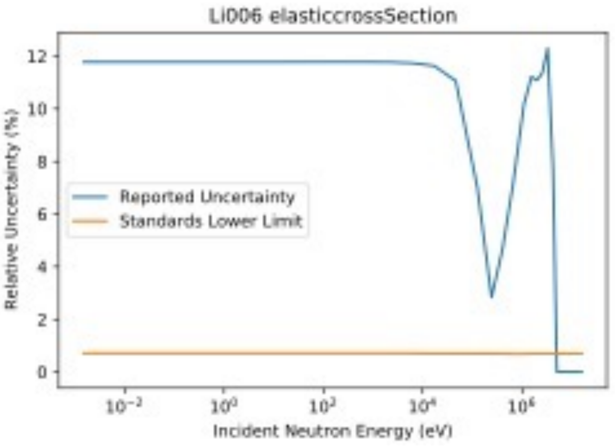
K-39, K-041, I-127, Fe-54, Co-59, Kr-86, Xe-132, Ce-140, Pr-141, Nd-143, Gd-160, Dy-161, Dy-163, Tm-170, Pb-207,

Failed |correlations| <= 1

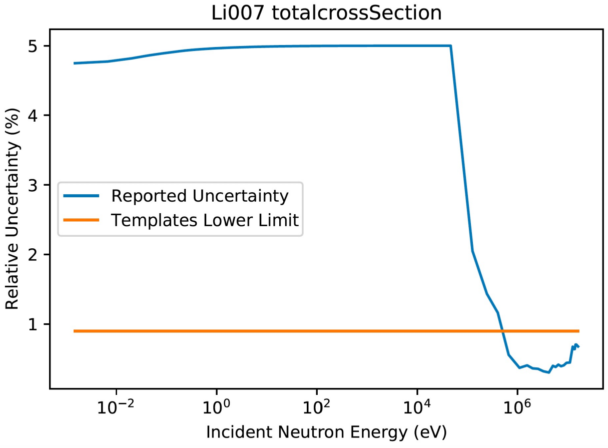
B-10, Li-06, Li-007, U-235, Na-23, Mg-024, Al-27, Si-29, Ti-46, Ti-47, Ti-48, U-233, Mn-55, Ni-58, Ni-60, Rh-103, Ce-142, Dy-156, Dy-158, Dy-160, Dy-162, Dy-164, Pb-206, Pu-239, Pu-240

Likely a problem of strong correlations leading to |correlations| ever so slightly >1 when transformed to 51-bin grid.

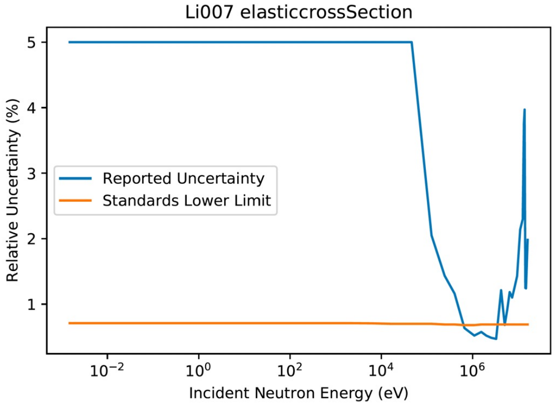
Possible “physics issues” in covariances.



Could the bins of uncertainties end too low in energy for ^{6}Li(n,el) cs covariances?

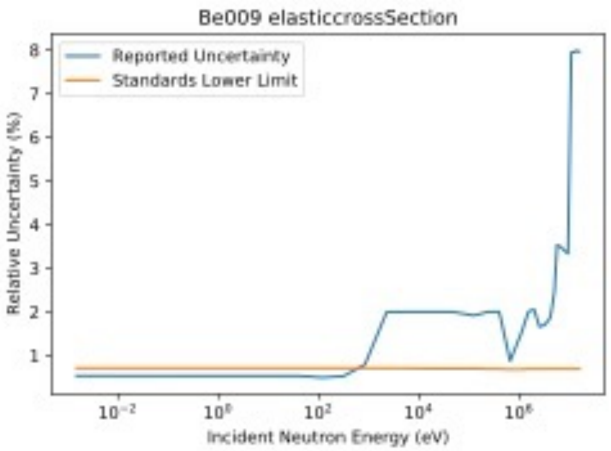


Is the ^{7}Li(n,tot) cs uncertainty realistic in size? It is below the ^{1}H(n,el) cs unc.

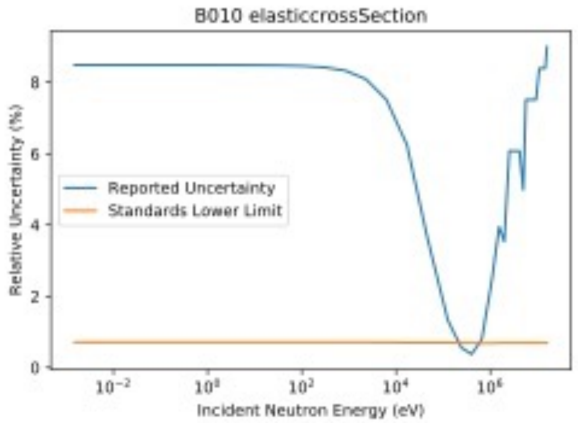


Is the ^{7}Li(n,el) cs uncertainty realistic in size? Do we know it better than the C(n, n) cs?

Possible "physics issues" in covariances.

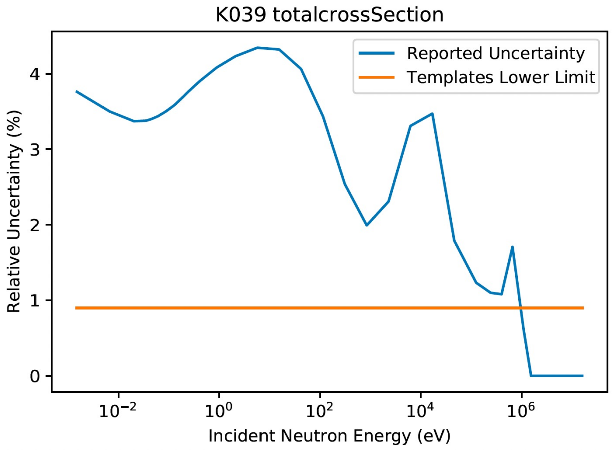


Is the ^{9}Be(n,el) cs uncertainty realistic in size? It is below the ^{1}H(n,el) cs unc.

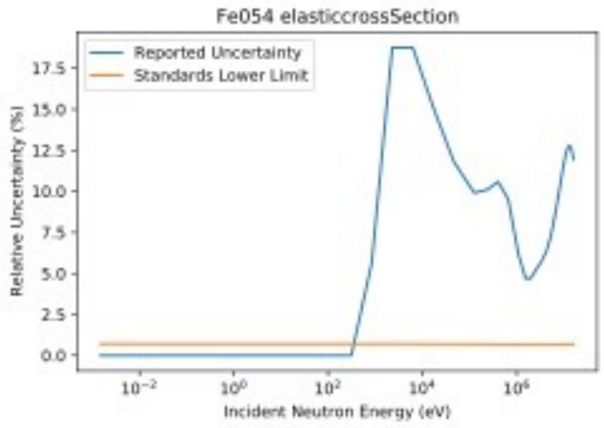


Is the ^{10}B(n,el) cs uncertainty realistic in size? Do we know it better than the C(n, n) cs?

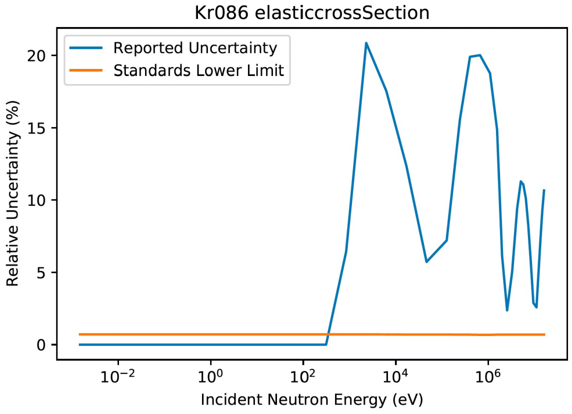
Missing covariances:



Is the ^{39}K(n,el) cs uncertainty zero above 2 MeV? Is there an issue in formatting, data, processing, or are fast covariances missing?

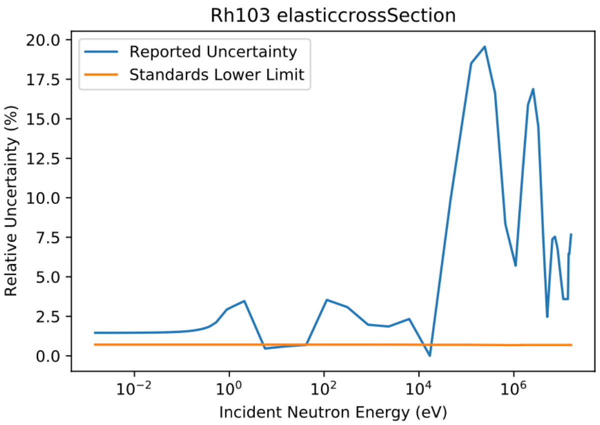


Why is the ^{54}Fe(n,el) uncertainty zero below 100 eV? Is there an issue in formatting, data, processing, or are RRR covariances missing?

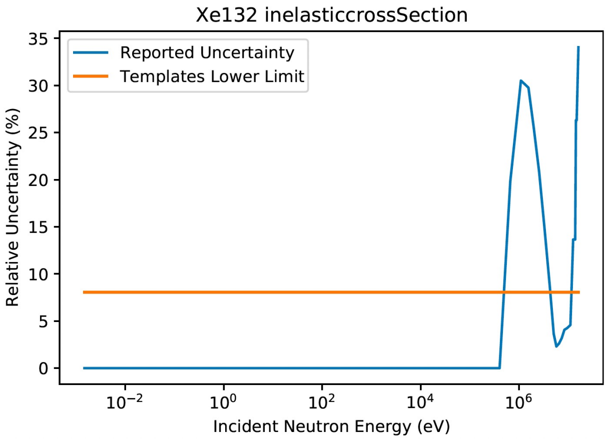


Is the ^{86}Kr(n,el) cs uncertainty zero below 100 eV? Is there an issue in formatting, data, processing, or are RRR covariances missing?

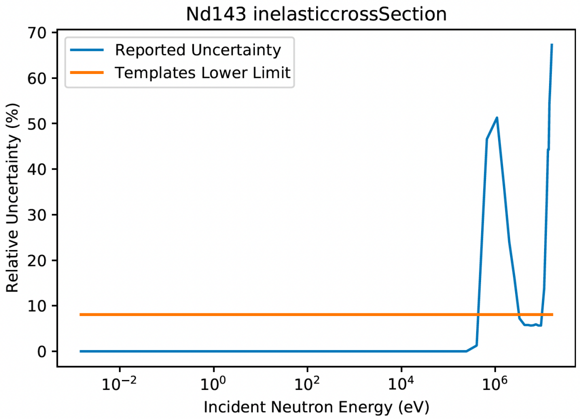
Possible “physics issues” in covariances.



Is the ^{103}Rh(n,el) cs uncertainty realistic in size? Do we know it better than the C(n, n) cs?

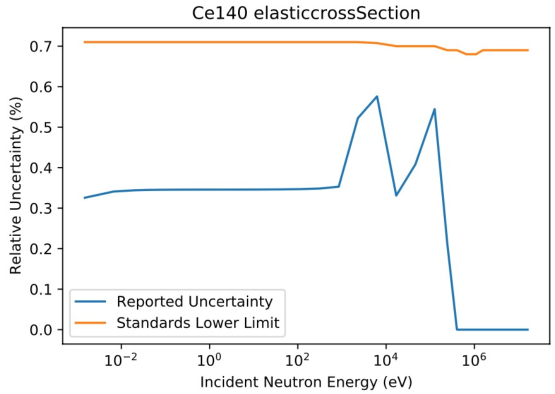


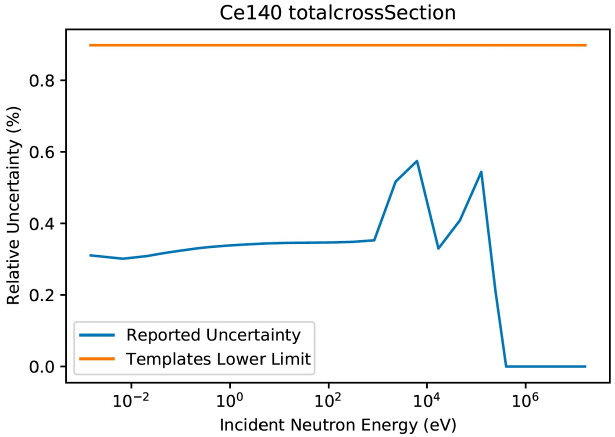
^{132}Xe(n,inl) cross section uncertainties have surprising structures that one might want to take a second look at.

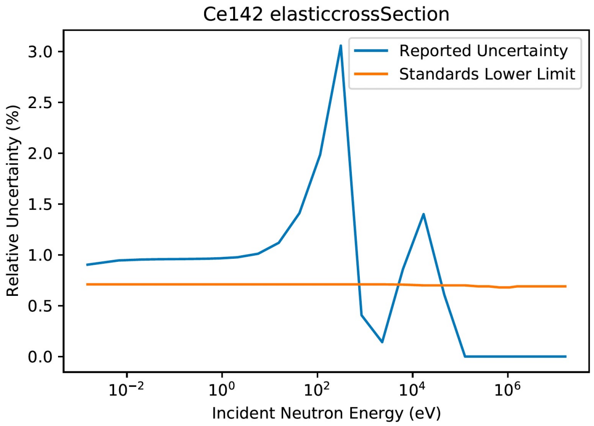


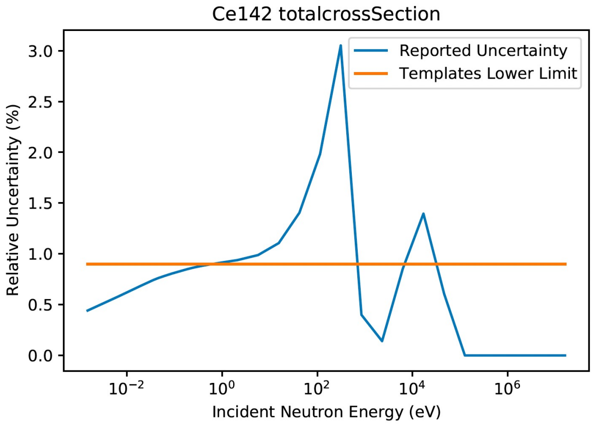
^{143}Nd(n,inl) cross section uncertainties have surprising structures that one might want to take a second look at.

Missing covariances and low uncertainties for Ce.





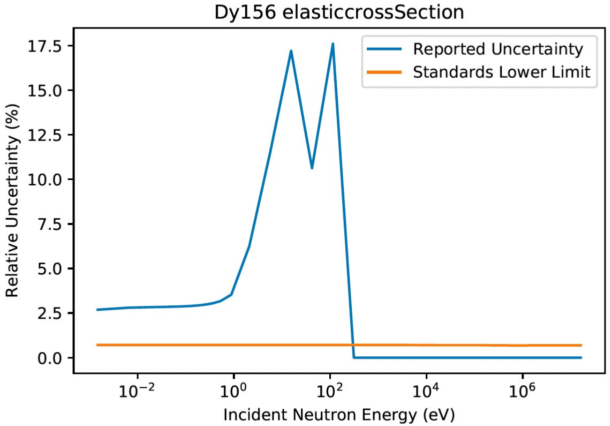




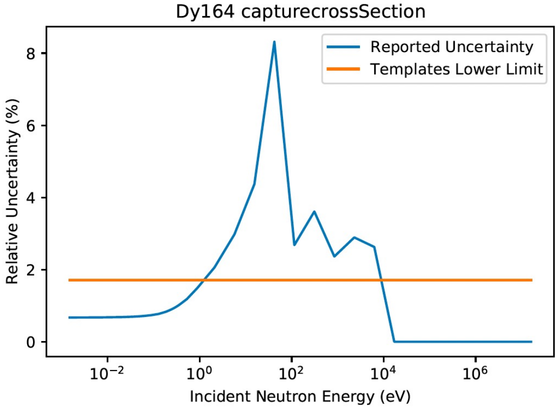
Are the $^{140/142}$Ce(n,el) and (n,tot) cs uncertainties realistic in size? Do we really know it better than the ^{1}H(n,n) or C(n, n) cs?

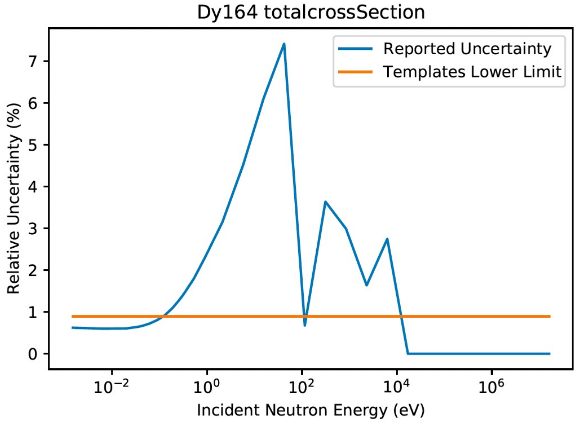
Also, why is it zero above 100 keV? Are we missing fast covariances?

Dy covariances: zero uncertainties for some fast cross sections. Processing, missing data, or formatting issue?



Why is the ^{156,158}Dy(n,el) uncertainty zero above 100 eV? Is there an issue in formatting, data, or processing, or are we missing fast covariances?

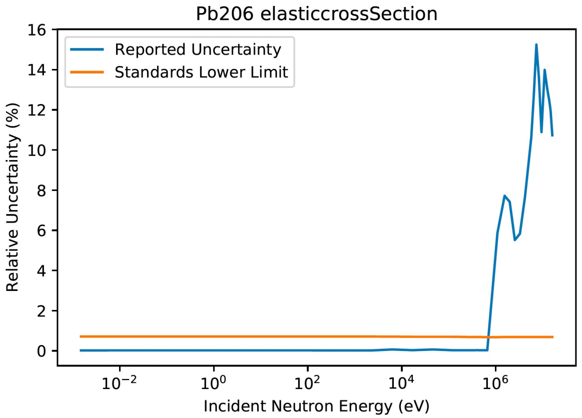


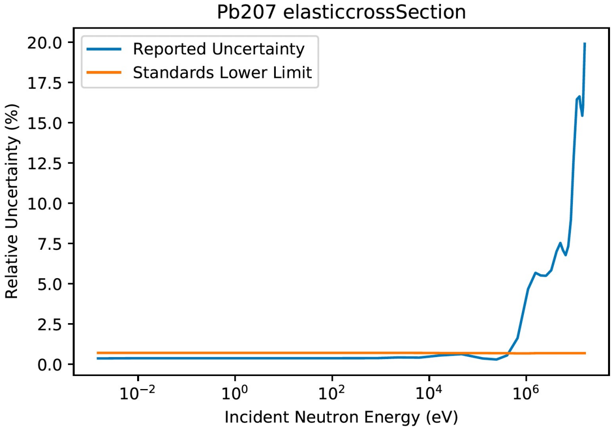


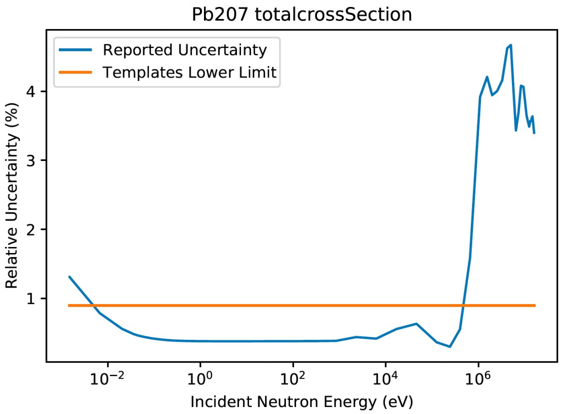
For $^{160\text{-}164}$Dy(n,el) zero uncertainties for E >1-10 keV for:

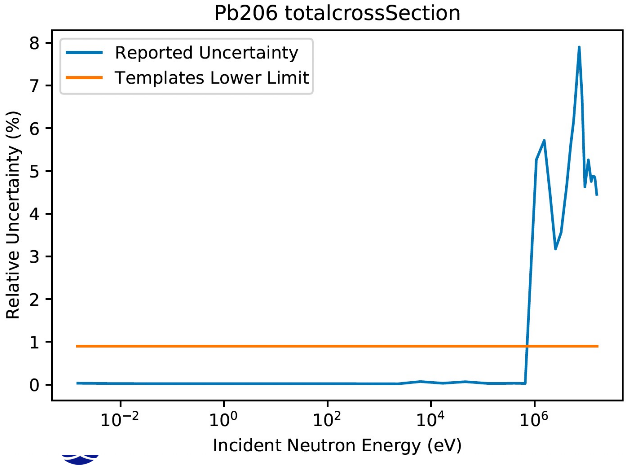
- (n,tot),
- (n,el),
- Capture.

Missing covariances and low uncertainties for Pb.



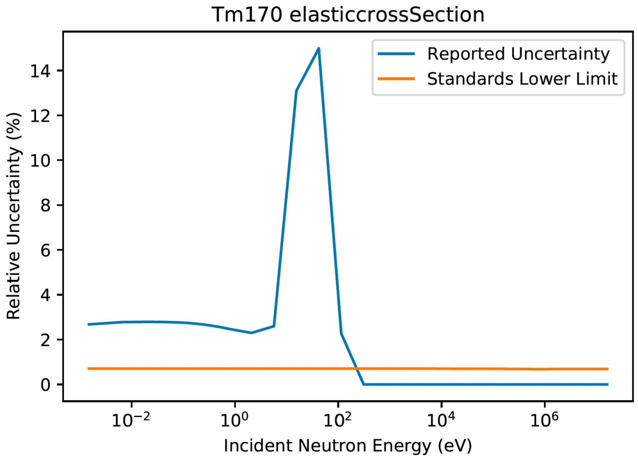




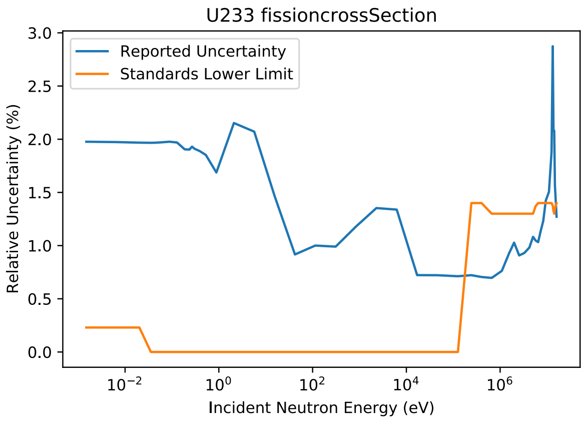


Are the $^{206/207}$Pb(n,el) and (n,tot) cs uncertainties realistic in size? Do we really know it better than the ^{1}H(n,n) or C(n, n) cs?

Possible "physics issues" in covariances.

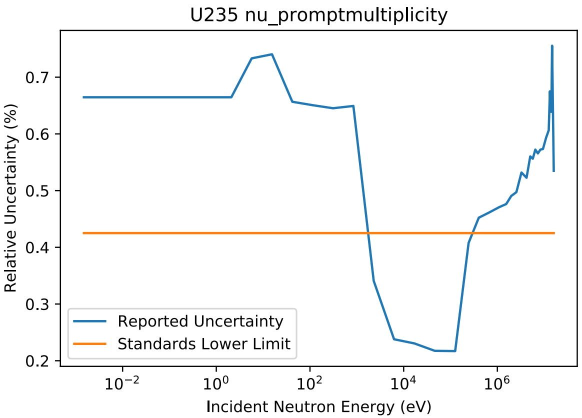


Is the ^{170}Tm(n,el) cs uncertainty zero above 1 keV? Is there an issue in formatting, data, processing, or are fast covariances missing?

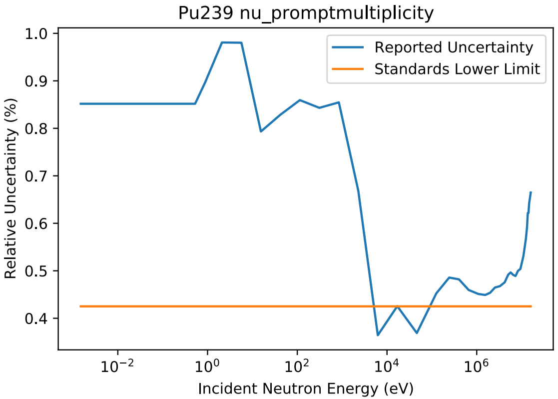


The ^{233}U(n,f) cross section and PFNS uncertainty is below the ^{235}U(n,f) cs and ^{252}Cf(sf) PFNS standard.

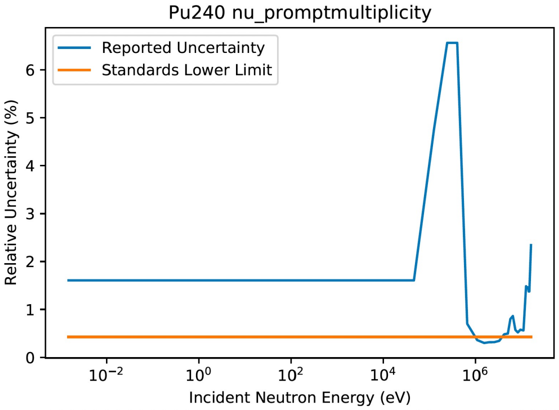
Possible “physics issues” in covariances.



The URR $^{235}U(n,f)$ nu-bar uncertainty is below the $^{252}Cf(sf)$ standard.



The URR $^{239}Pu(n,f)$ nu-bar uncertainty is below the $^{252}Cf(sf)$ standard.



The fast $^{240}Pu(n,f)$ nu-bar and (n,f) cs uncertainty is below the $^{252}Cf(sf)$ nu-bar and $^{235}U(n,f)$ cs standard.

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