Los Alamos NATIONAL LABORATORY

New nuclear data proposed for the ^{238}U nu-bar, ^{235}U nu-bar and PFNS

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CSEWG November 2022

LA-UR-22-31314

Thanks to the following collaborations: Chi-Nu, CGMF, fissionTPC, Neutron Data Standards, NNSA/ CEA collaboration, Templates

^{235}U(n,f) PFNS

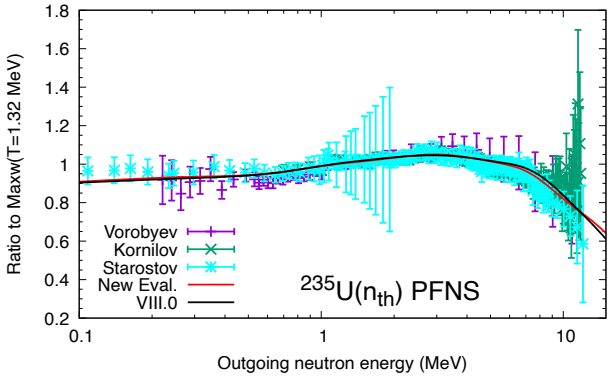
References: Neudecker, Kelly, LA-UR-22-22220; DN et al., NDS 148, p. 293 (2018).

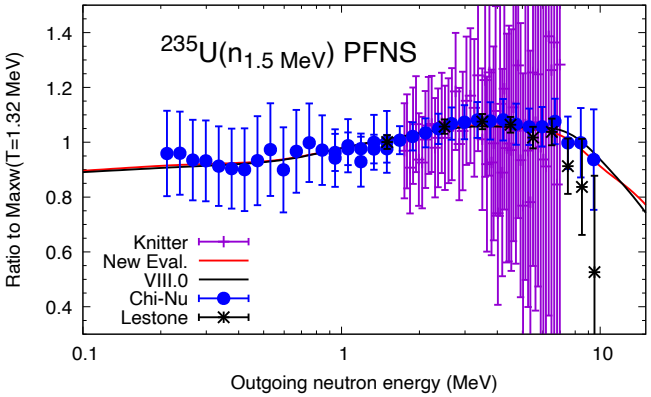
Thanks to: Devlin, Haight, Kawano, Kelly, Lee, Marini, Mosby, O'Donnell, Taddeucci, Taieb, Talou, White, Wu

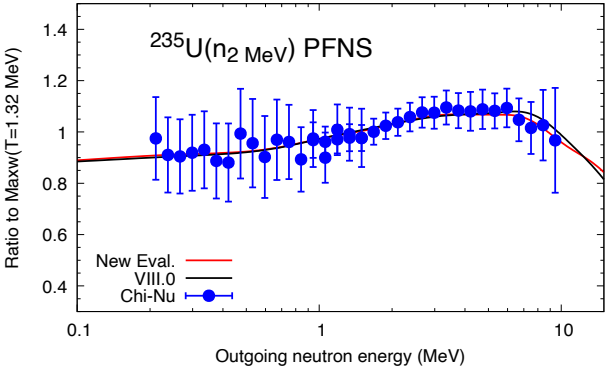
We are performing an evaluation of the ^{235}U PFNS with new exp. data as from Chi-Nu collaboration.

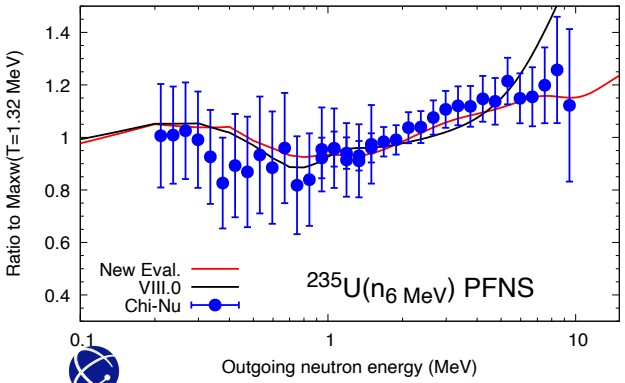
- Codes: ARIADNE, Neudecker evaluation code,
- Prior: Los Alamos and exciton model (in CoH) included via GLS, same model included for VIII.0,
- Evaluation technique: GLS,
- Experimental data:
  - Same data that were considered for VIII.0,
  - Includes new high-precision experimental data by Chi-Nu across E_{inc} and E_{out}.

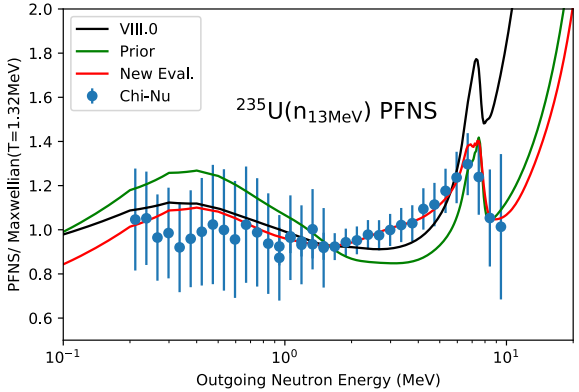
PFNS very similar to ENDF/B-VIII.0 for E_{inc} < 5 MeV, above we see distinct changes.

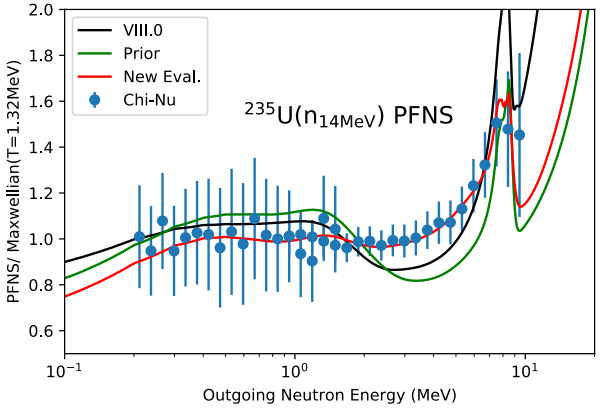




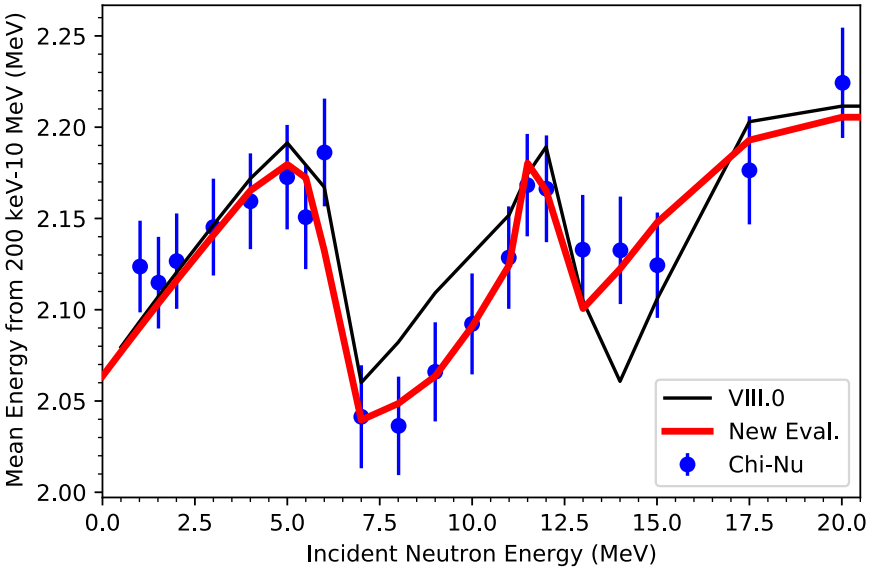


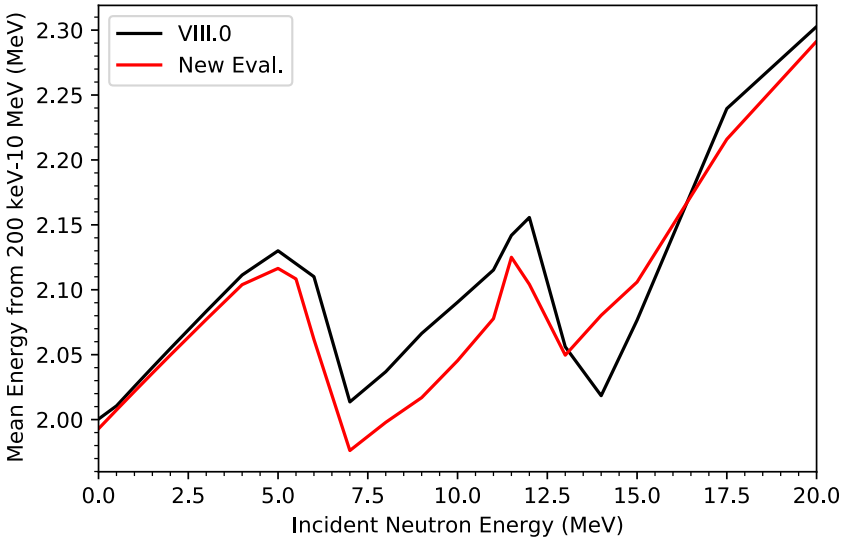




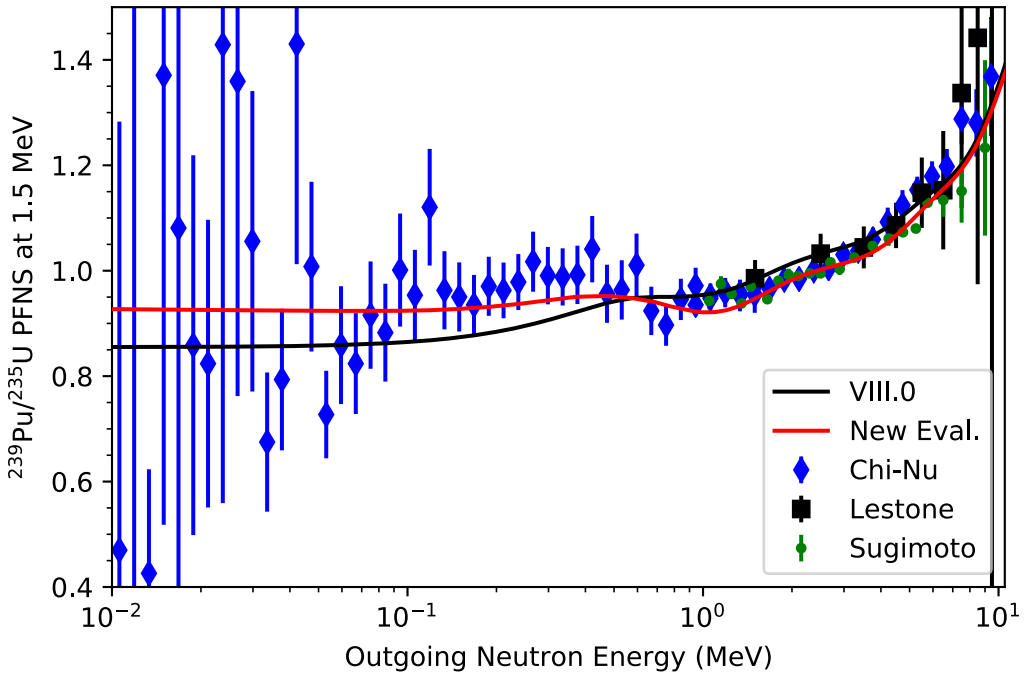


Mean energies compare well to Chi-Nu experimental data.





Ratio $^{239}Pu/^{235}U(n,f)$ PFNS at E_{inc} = 1.5 MeV looks ok.



^{235}U(n,f) nu-bar

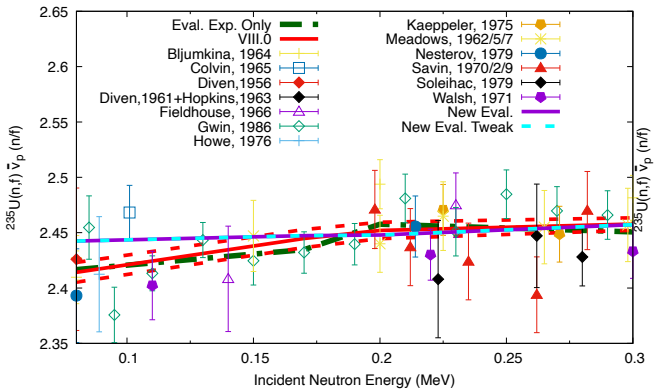
References: Lovell, Neudecker, Talou, LA-UR-22-23475

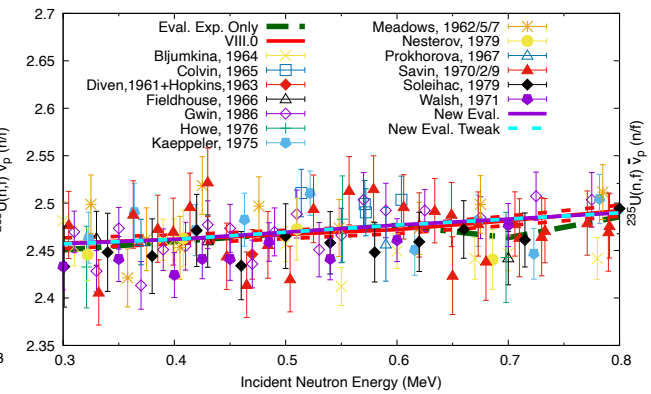
Thanks to: A. Lovell, P. Talou.

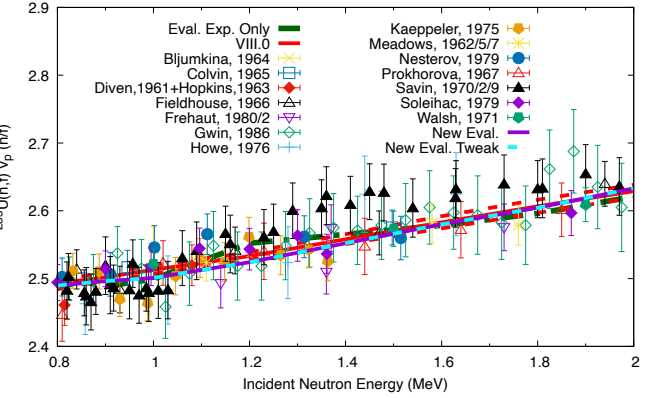
We are performing an evaluation of the ^{235}U nu-bar with new exp. data, improved exp. UQ & CGMF as input.

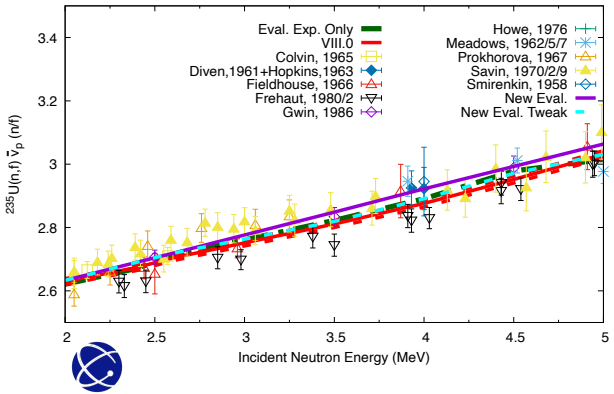
- Codes: ARIADNE, CGMF,
- Prior: CGMF model included via Kalman and sensitivities of CGMF model parameters to nu-bar, no model included for VIII.0,
- Evaluation technique: Kalman including correction for PPP,
- Experimental data:
  - New experimental data since VIII.0 include at least Khoklov and Boikov,
  - New UQ for all experimental data,
  - templates of expected measurement uncertainties were applied,
  - Some correlations between unc. of different exp., except for ^{252}Cf(sf) nu-bar uncertainty cross-correlating all uncertainties.

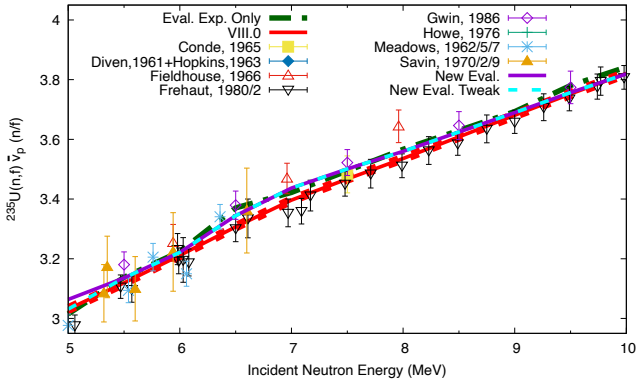
Evaluated ^{235}U nu-bar, with an without CGMF, is very similar to ENDF/B-VIII.0, tweak could be needed from 2.5-5 MeV.

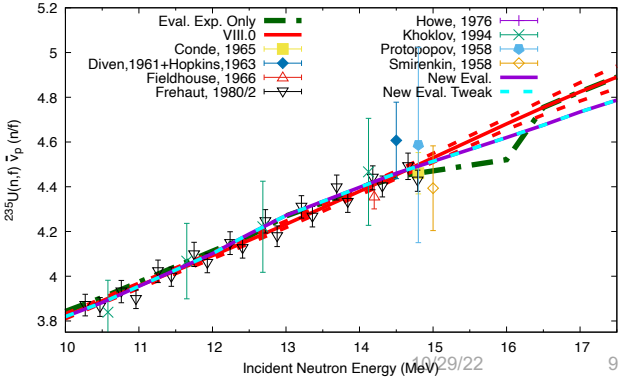




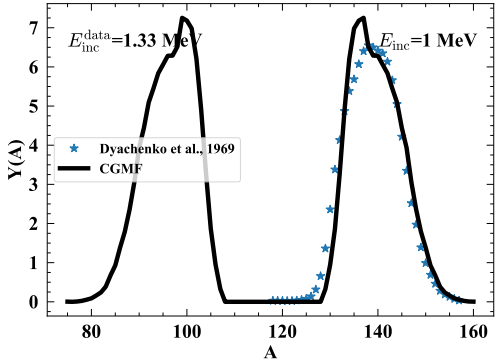


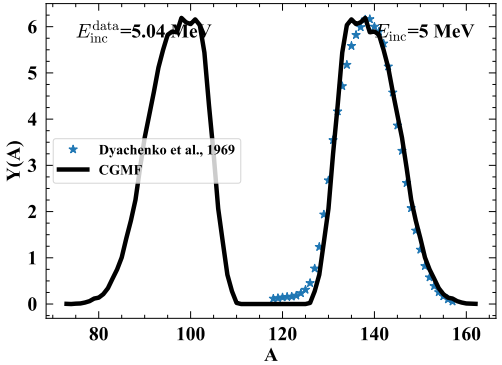


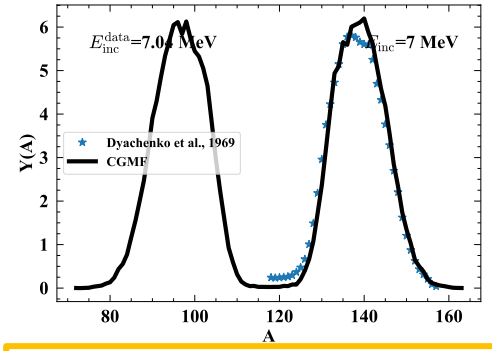


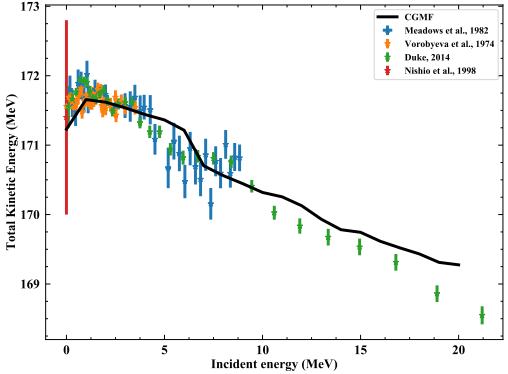


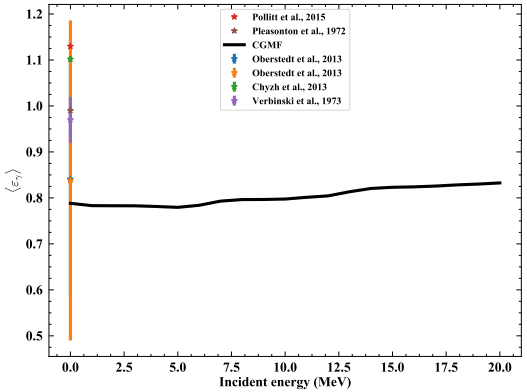
The evaluated parameters link favorably back to other fission quantities, except for PFNS, using CGMF.

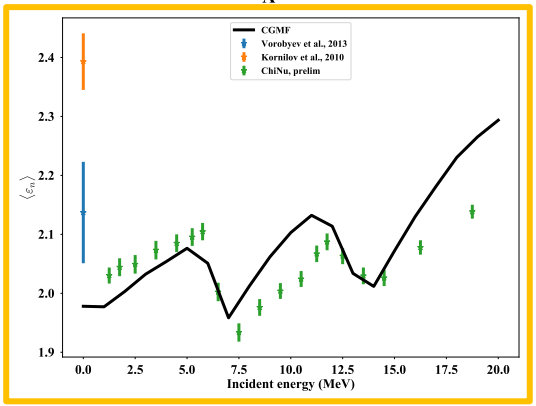












Using CGMF for evaluations brings the added benefit that we can link back nu-bar to Y(A), TKE(A), etc. to see if they are all consistent and realistic.

^{238}U(n,f) nu-bar

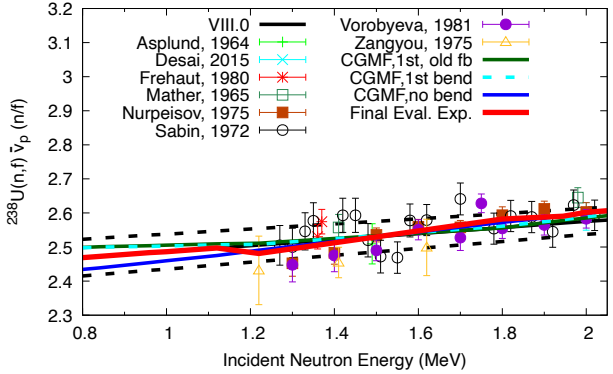
References: Neudecker, Lovell, Kawano, Talou, LA-UR-22-29906

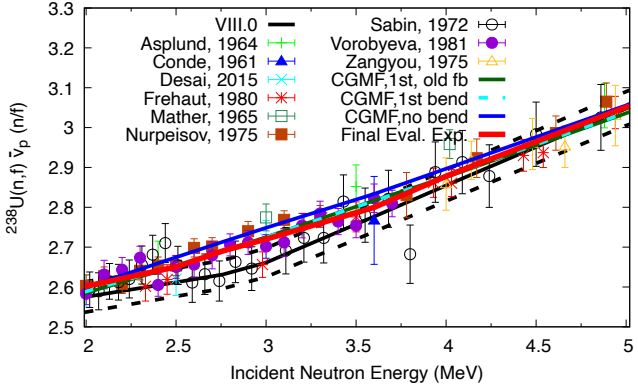
Thanks to: A. Lovell, I. Setcu, T. Kawano, P. Talou.

We are performing an evaluation of the ^{238}U nu-bar with new exp. data, improved exp. UQ & CGMF as input.

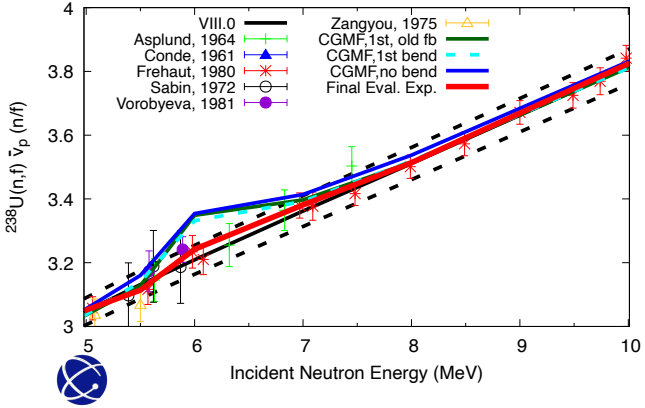
- Codes: ARIADNE, CGMF,
- Prior: CGMF model included via Kalman and sensitivities of CGMF model parameters to nu-bar, no model included for VIII.0,
- Evaluation technique: Kalman including correction for PPP,
- Experimental data:
  - VIII.0 was based on Frehaut mostly, no detailed analysis of all past data,
  - New UQ for all experimental data,
  - templates of expected measurement uncertainties were applied,
  - Some correlations between unc. of different exp., except for ^{252}Cf(sf) nu-bar uncertainty cross-correlating all uncertainties.

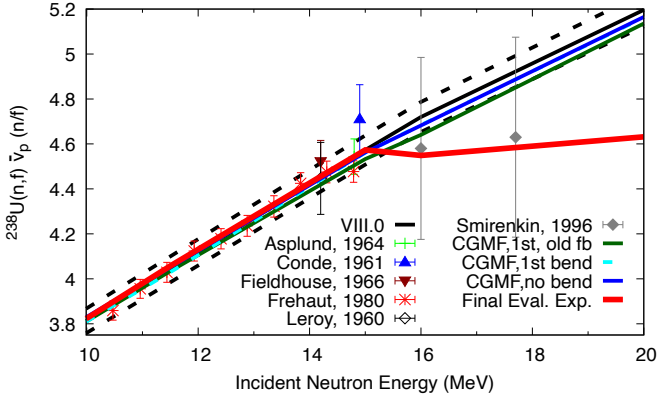
Evaluated ^{238}U nu-bar, with an without CGMF, is very different from ENDF/B-VIII.0 from 2-4 MeV. Work on 2nd c.f. needed.

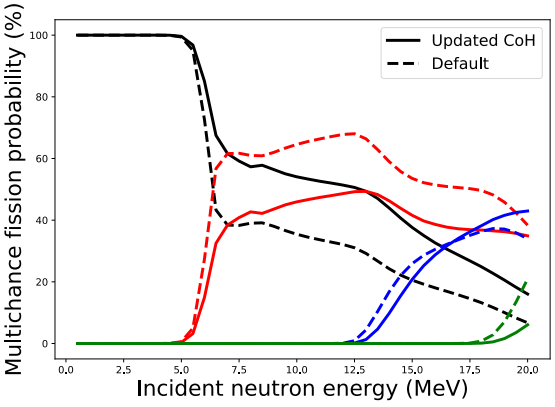




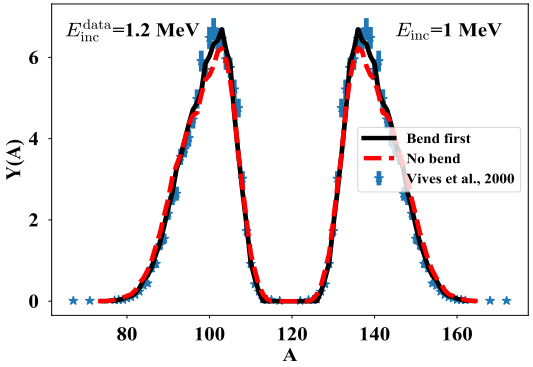
Need to counter-balance change in nu-bar by PFNS. Chi-Nu data come FY23 Exp. nu-bar to be measured by CEA.

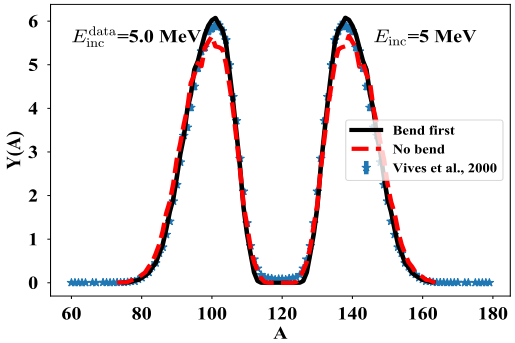


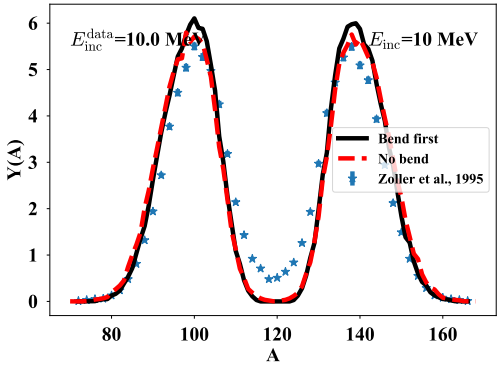


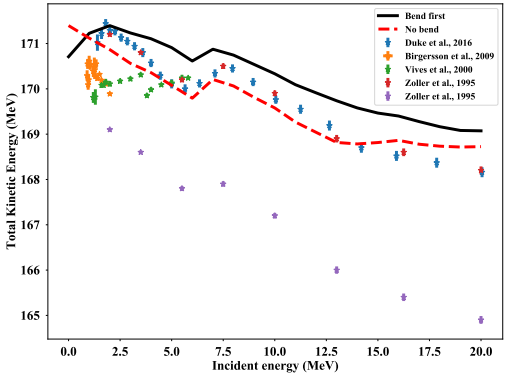


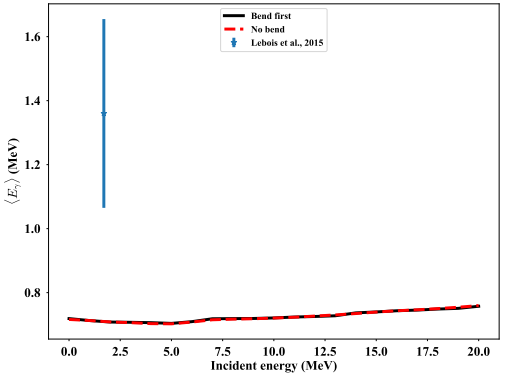
The evaluated parameters link favorably back to other fission quantities, except for PFNS, using CGMF.

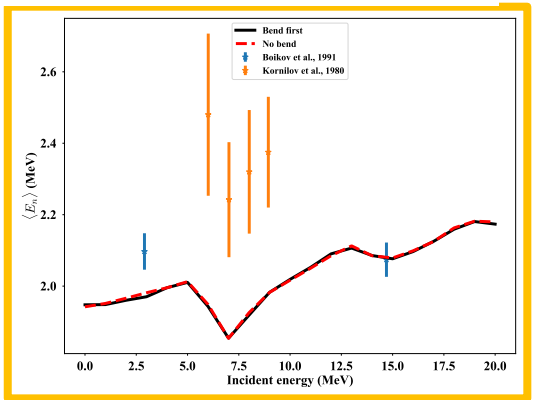












We are doing reasonably fine in describing Y(A), but <TKE> not as well-described. New experimental nu-bar will help.

Summary and outlook:

- Thanks to collaborative efforts (Chi-Nu, CGMF, NNSA/ CEA collaboration, Templates), we were able to improve nuclear data for the ^{235}U PFNS and nu-bar,
- Work at LANL will focus now on understanding ^{238}U(n,f) nu-bar, PFNS will be updated in the next few months.

Thank you for letting me speak!

Work at LANL was carried out under the auspices of the National Nuclear Security Administration (NNSA) of the U.S. Department of Energy (DOE) under contract 89233218CNA000001. We gratefully acknowledge partial support of the Advanced Simulation and Computing program at LANL and the DOE Nuclear Criticality Safety Program, funded and managed by NNSA for the DOE. NCERC is supported by the DOE Nuclear Criticality Safety Program, funded and managed by the National Nuclear Security Administration for the Department of Energy.

^{235}U(n,f) nu-bar and PFNS validation

Thanks to: Frankle, Kahler, Kawano, White.

Evaluated nu-bar and PFNS lead to small changes in k_{eff} of a few HEU and IEU MET-FAST experiments.

Table II: Simulated and experimental k_{eff} values are compared with each other for ENDF/B-VIII.0, ENDF/B-VIII.0 with the new PFNS for E_{inc}=0.5–30 MeV and ENDF/B-VIII.0 with the new PFNS for E_{inc}=0.5–30 MeV and a tweaked $\overline{\nu}_p$ from Resf. [27, 28]. An abbreviated ICSBEP nomenclature is used to identify the ICSBEP critical assembly [7]. HMF001 is the Godiva assembly, HMF028 is Flattop, IMF1 is Jemima and IMF7 is BigTen.

Benchmark	Exp.	Exp. Unc. (pcm)	VIII.0	PFNS	PFNS -VIII.0 (pcm)	$\overline{\nu}$+PFNS	($\overline{\nu}$+PFNS) -VIII.0 (pcm)	MC Unc. (pcm)
HMF001	1	100	1.00016	0.99964	-52	1.00047	31	8
HMF028	1	300	1.00092	1.00052	-40	1.00104	12	9
IMF1.1	0.9988	90	0.99888	0.99859	-29	0.9989	2	9
IMF1.2	0.9988	90	0.99919	0.99871	-48	0.99921	2	9
IMF1.3	0.999	30	0.99824	0.99786	-38	0.99812	-12	9
IMF1.4	0.999	30	0.9992	0.99895	-25	0.99914	-6	9
IMF7d	1.0045	70	1.00433	1.00402	-31	1.00421	-12	7

Evaluated PFNS improves simulated neutron leakage spectra of LLNL pulsed spheres.