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Title: Evaluations of the 239Pu Fission Source Term

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Report
Web

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Evaluations of the ^{239}Pu Fission Source Term

Denise Neudecker

NCSP TPR, 2/25/21

LA-UR-21-21474

This work shows progress towards fulfilling NCSP milestones of LANL ND1 (Nuclear Data Evaluation and Testing).

Thanks to: M.B. Chadwick, M. Devlin, K. Kelly, R.C. Little, A. Lovell, P. Marini, L. Snyder, J. Taieb, P. Talou.

^{239}Pu/^{235}U(n,f) cross sections by niffteTPC were included in Neutron Data Standards' database

- Deliverable FY21: "Update fission cross section based on TPC results (from ^{239}Pu/^{235}U ratio data)" → Snyder et al., to be submitted to NDS. (high-precision (n,f) cross-section exp. campaign led by LLNL, executed at LANSCE)
- Deliverable FY20: "Update fission cross section based on TPC results (from ^{238}U/^{235}U ratio data)" → Casperson et al., PRC 97, 034618 (2018)
- Why do these data matter:
  - TPC data employ new type of fission detector possibly uncovering systematic issues in wealth of previous exp. data mostly measured with fission chambers
  - High-precision measurement explores uncertainty source

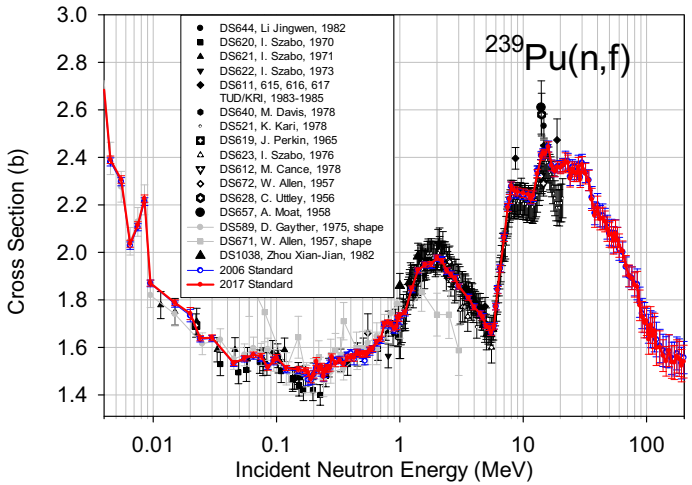


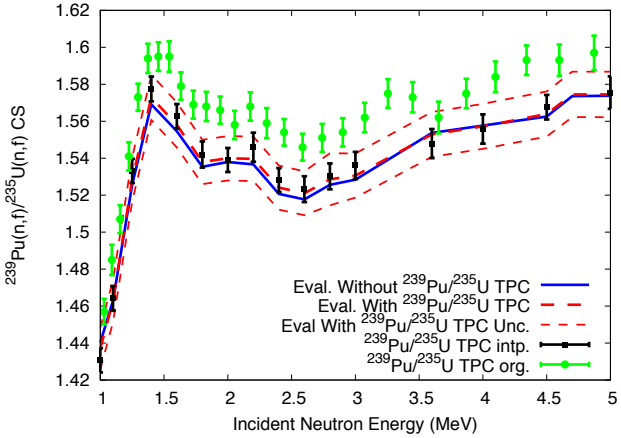
Fig. from Carlson et al., NDS 148, 143 (2018).

$^{239}Pu/^{235}U(n,f)$ cross sections by niffteTPC were included in Neutron Data Standards' database

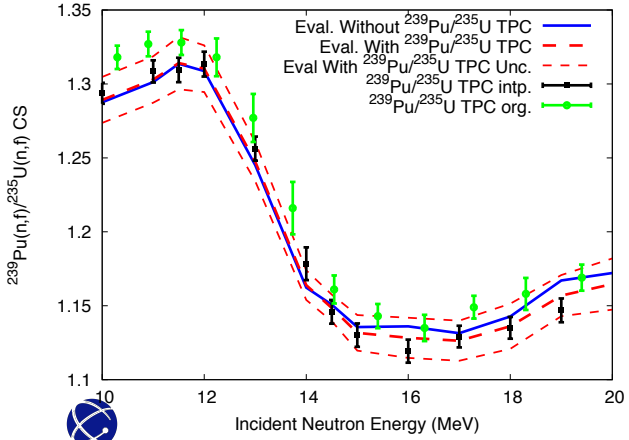
- **<u>Deliverable FY21:</u> "Update fission cross section based on TPC results (from $^{239}Pu/^{235}U$ ratio data)" → Snyder et al., to be submitted to NDS.**
- <u>Deliverable FY20:</u> "Update fission cross section based on TPC results (from $^{238}U/^{235}U$ ratio data)" → Casperson et al., PRC 97, 034618 (2018)
- <u>Why do these data matter:</u>
  - TPC data employ new type of fission detector possibly uncovering systematic issues in wealth of previous exp. data mostly measured with fission chambers
  - High-precision measurement explores uncertainty source

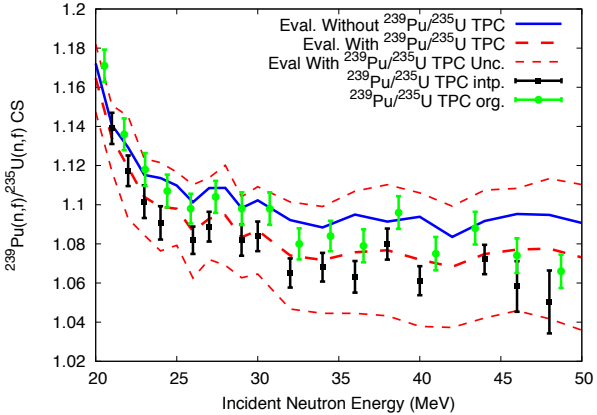
See back-up slides.

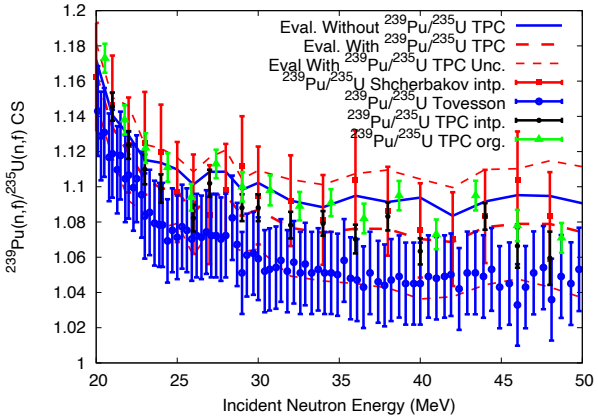
^{239}Pu/^{235}U(n,f) niffteTPC data significantly change nuclear data > 10 MeV and raise questions about past data.



- TPC intp … TPC data after standard interpolation, and normalization procedure.
- TPC org … as reported by niffteTPC collaboration.
- Eval. Without TPC … current standard file.

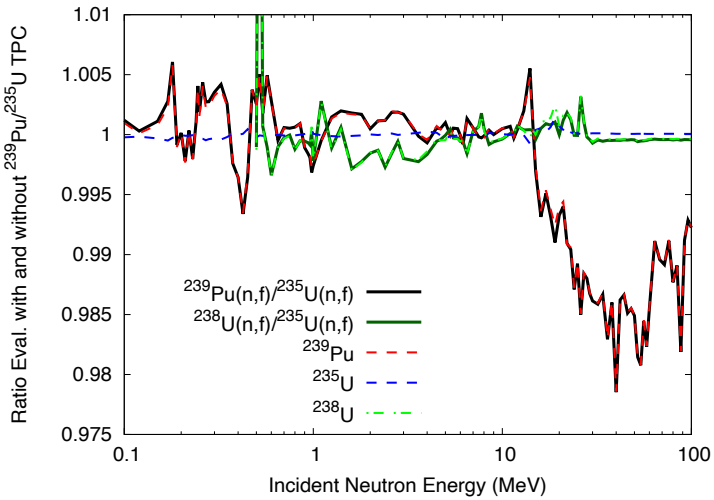




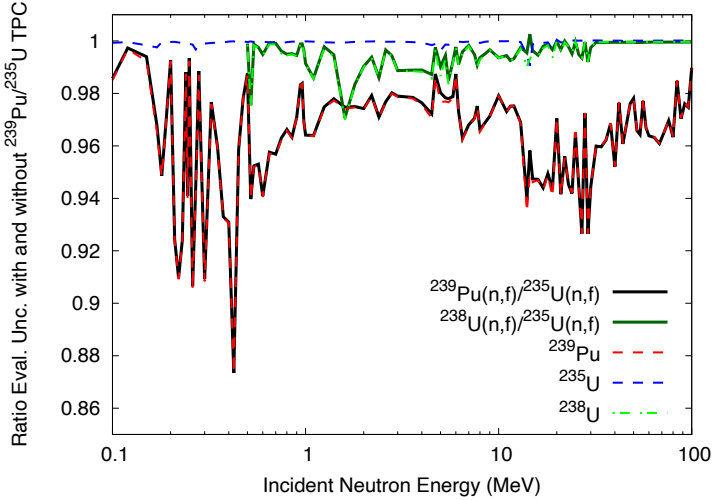


(n,f) cross section nu-bar PFNS

niffteTPC exp. results change nuclear data < 10 MeV within 0.5% and reduce unc. up to 12%.



niffteTPC data mostly impact ^{239}Pu(n,f) and ^{238}U(n,f) cs.

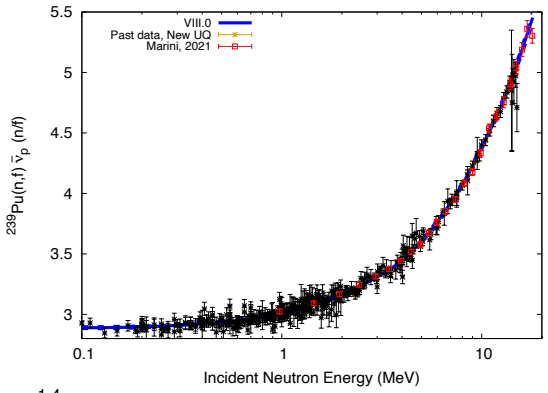


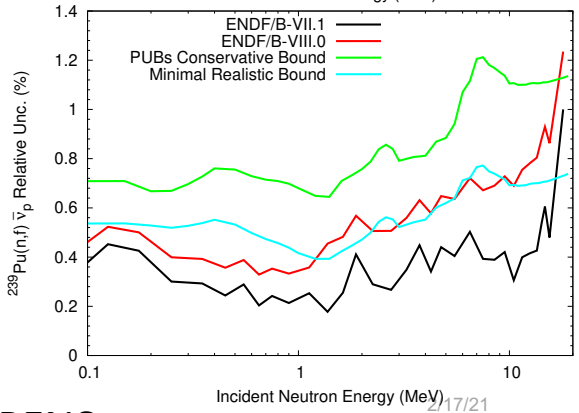
To-Do:

- Prepare final report for standards,
- Finalize inclusion with Neutron Data Standards committee,
- Re-visit discussion on previous data > 10 MeV,
- Caveat: TPC data might change during review process.

^{239}Pu(n,f) nu-bar is being re-evaluated to include new model, experimental data, and improve uncertainty estimate.

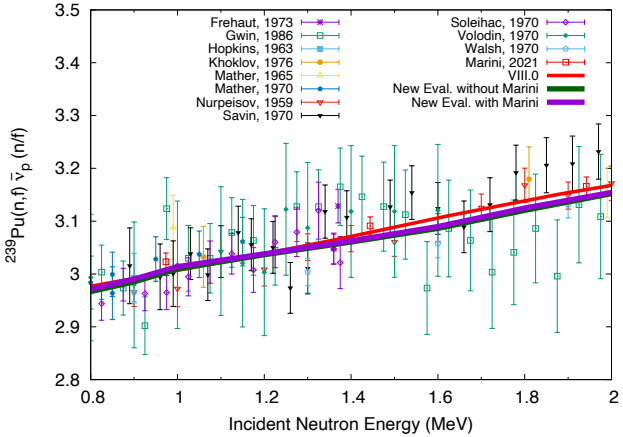
- Deliverable FY21: "Evaluate PFNS and multiplicity consistently, including angular information about prompt neutrons".
- Co-funded by ASC-PEM-NP.
- Motivation for re-visit:
  - Implement CGMF model (talk by Lovell),
  - New data by Marini et al. (CEA) from 1-700 MeV, unc.: 0.7-1.2%, past data used liquid-scintillator technique, these data extracted from PFNS,
  - VIII.0 nu-bar unc. likely too small.
- Plan forward:
  - Re-produce previous mean value for consistency,
  - Experiments: include new data, better UQ,
  - Model: include CGMF.

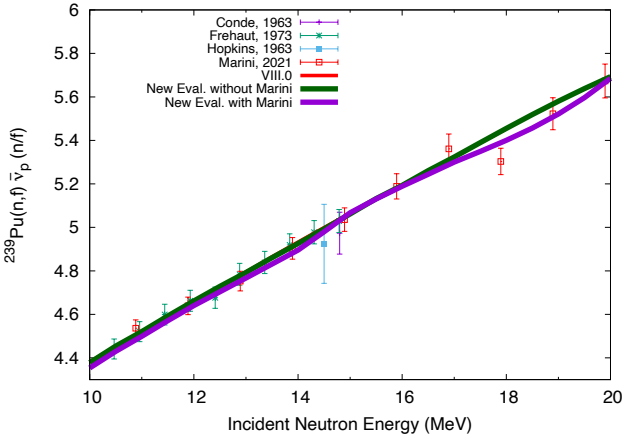




(n,f) cross section **nu-bar** PFNS

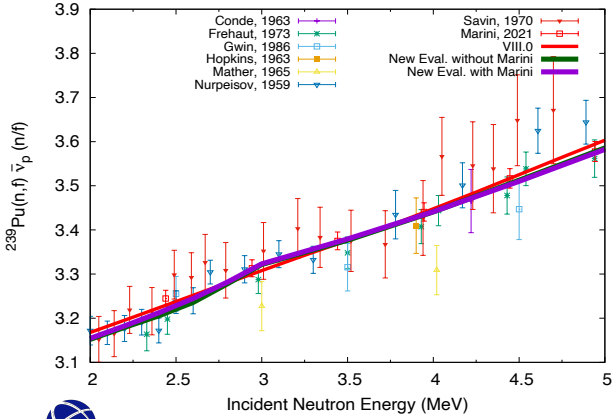
We reproduced previous ^{239}Pu(n,f) prompt nu-bar data, got more realistic uncertainties and included Marini data.

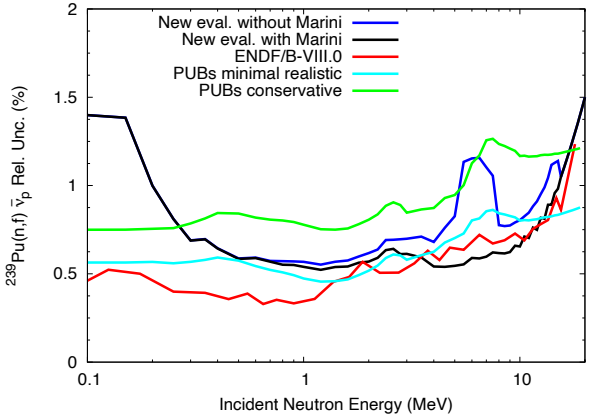




To-Do:

- Some more UQ across experiments,
- Include CGMF model,
- Apply to ^{235}U(n,f) nu-bar.



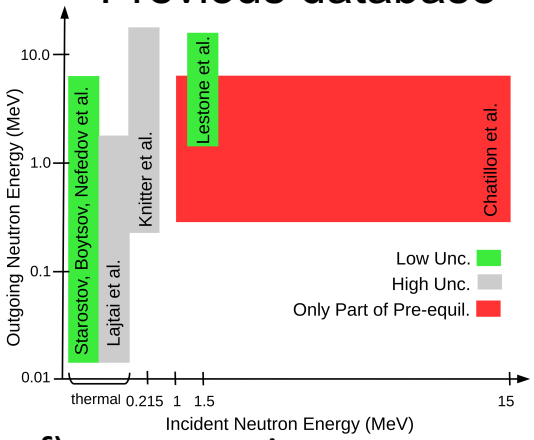


(n,f) cross section **nu-bar** PFNS

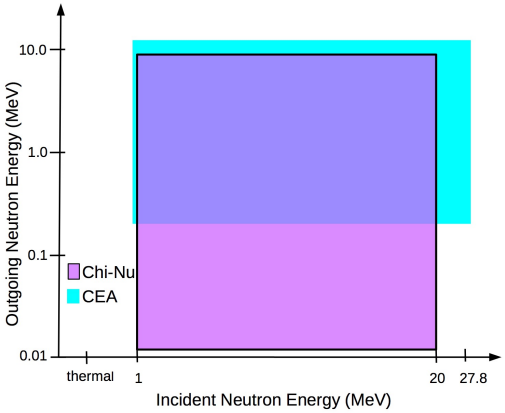
^{239}Pu(n,f) PFNS is being re-evaluated to include new model and high-impact Chi-Nu (LANL-led) and CEA exp. data.

- Deliverable FY21: "Evaluate PFNS and multiplicity consistently, including angular information about prompt neutrons".
- Co-funded by ASC-PEM-NP.
- Motivation for re-visit:
  - Implement CGMF model (talk by Lovell),
  - Include high-impact Chi-Nu and Marini (CEA) PFNS (high-precision, large energy-range).

Previous database



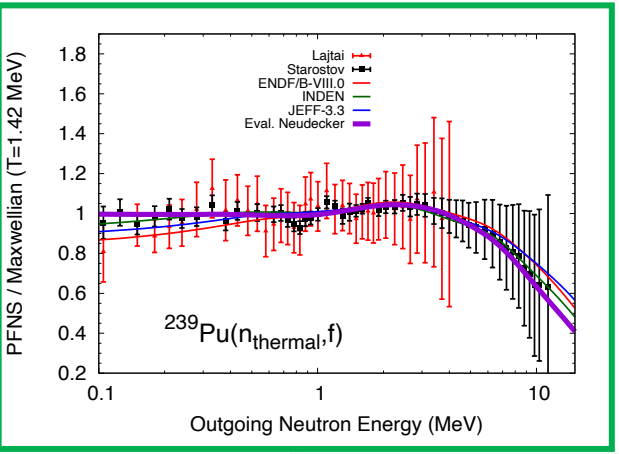
Additional data

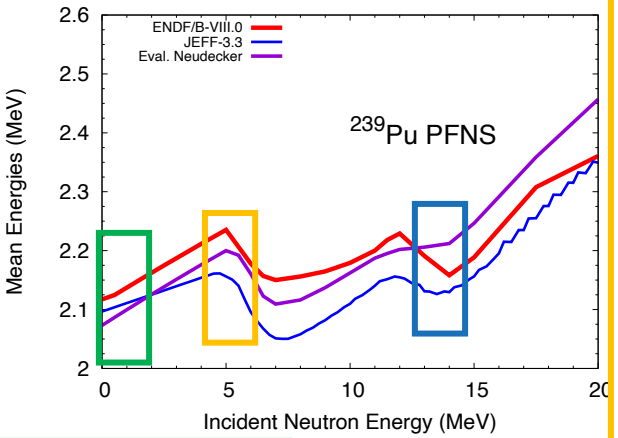


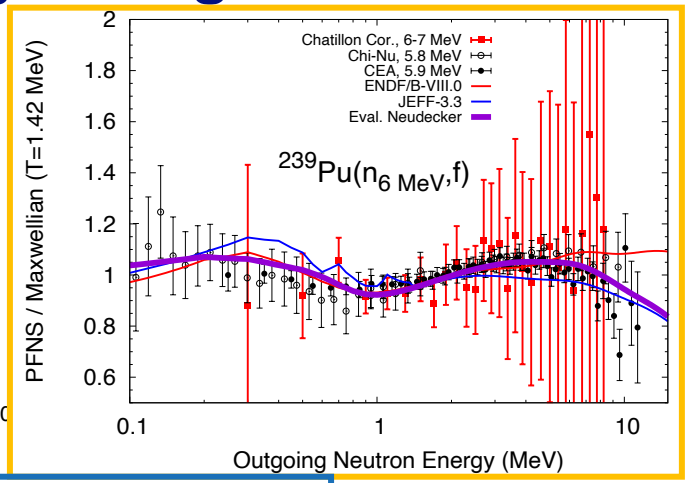
→ Both data sets were taken at LANSCE with the Chi-Nu array as part of a NNSA/CEA collaboration.

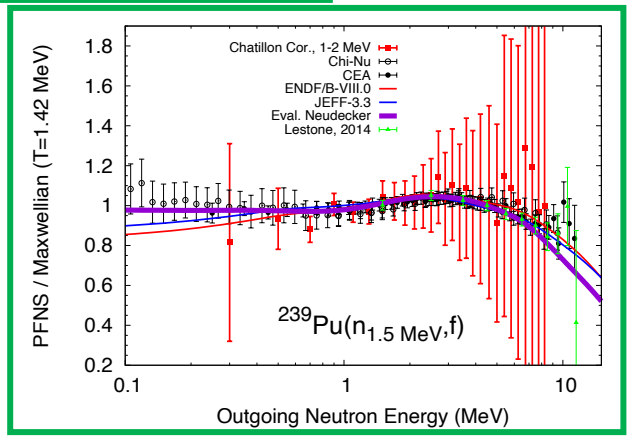
(n,f) cross section nu-bar **PFNS**

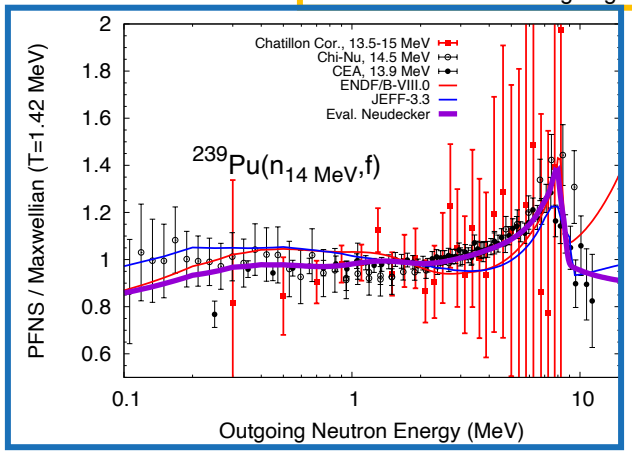
^{239}Pu PFNS by Chi-Nu and CEA distinctly change evaluation.











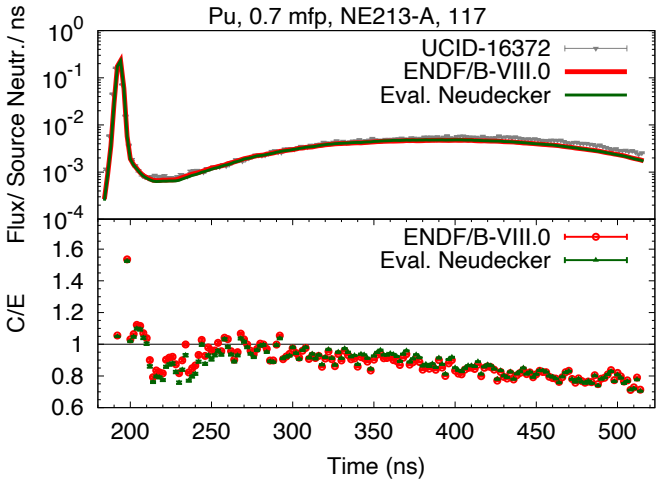
(n,f) cross section

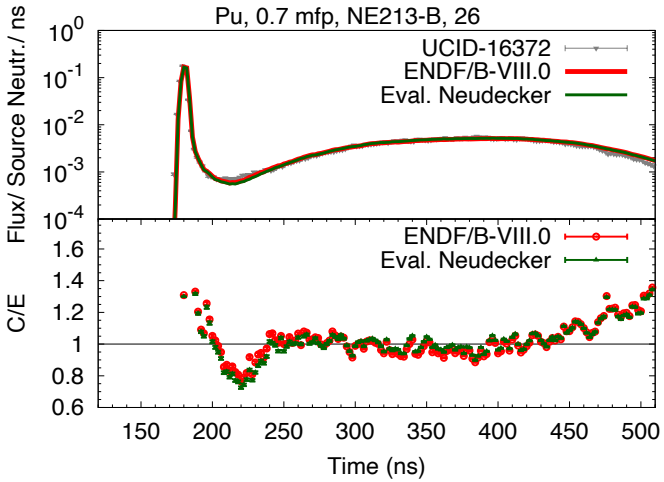
nu-bar

PFNS

New PFNS changes simulated criticality and pulsed-sphere neutron-leakage spectra. We will need to counter-balance.

	Jezebel	Flattop	PMI-002
VIII.0	0.998981(8)	0.99978(10)	1.00409
VIII.0+ new PFNS (VIII.0 nu-bar + cs!)	0.99782(8)	0.99756(10)	1.00495(12)





(n,f) cross section nu-bar **PFNS**

Summary

- ^{239}Pu/^{235}U(n,f) niffteTPC data included into standards.
- ^{239}Pu(n,f) nu-bar re-evaluated with more realistic uncertainties and including recent CEA data.
- ^{239}Pu PFNS by Chi-Nu and CEA included.

These new exp. data partially change our understanding of nuclear data. We will need to carefully study benchmark simulations once the evaluations are final.

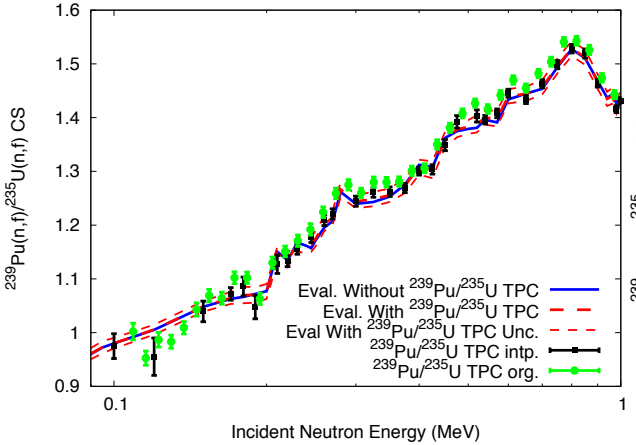
To-Do:

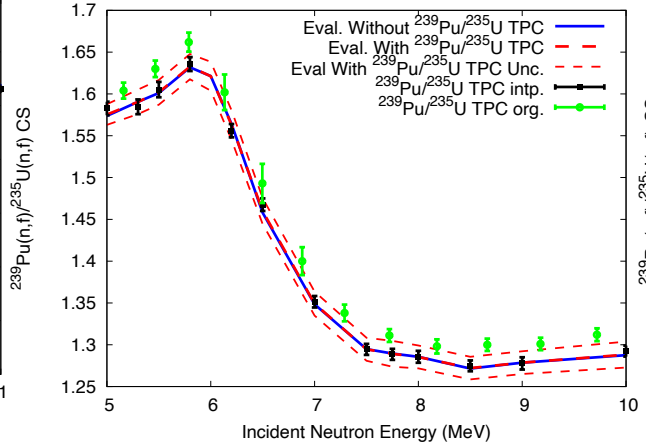
- Inclusion of CGMF model into nu-bar and PFNS evaluations,
- Include ^{235}U Chi-Nu PFNS,
- ^{235}U(n,f) nu-bar evaluation.
- Benchmarking.

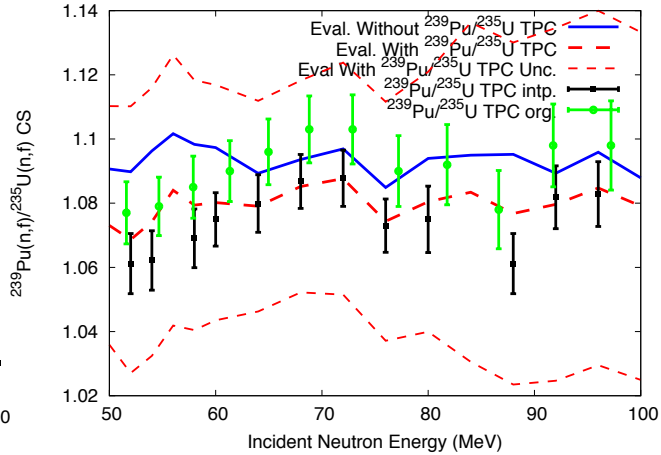
Thank you for your attention!

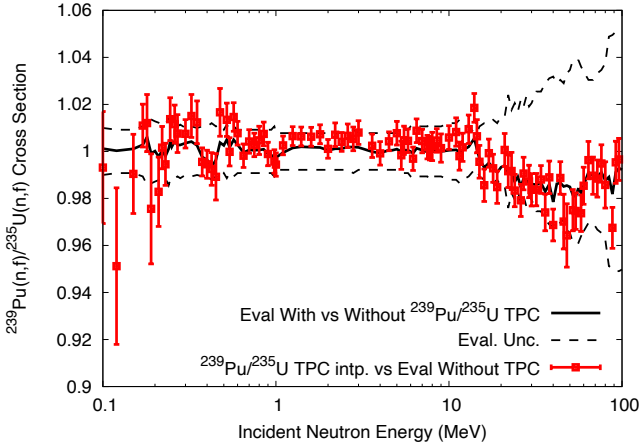
This work was supported in part by the DOE Nuclear Criticality Safety Program, funded and managed by the NNSA for the Department of Energy.
We gratefully acknowledge the support of the Advanced Simulation and Computing (ASC) program at Los Alamos National Laboratory.

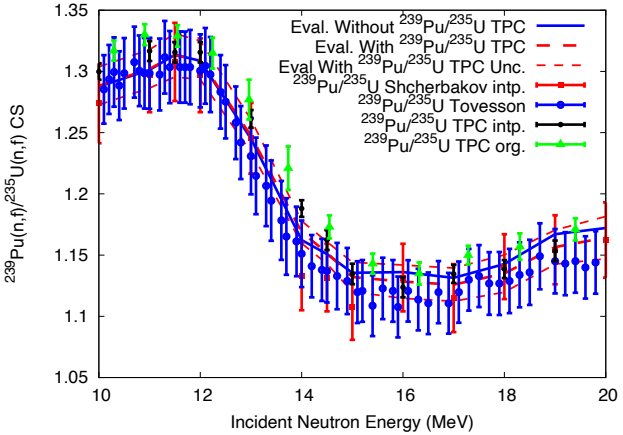
^{239}Pu/^{235}U(n,f) niffteTPC data included in standards

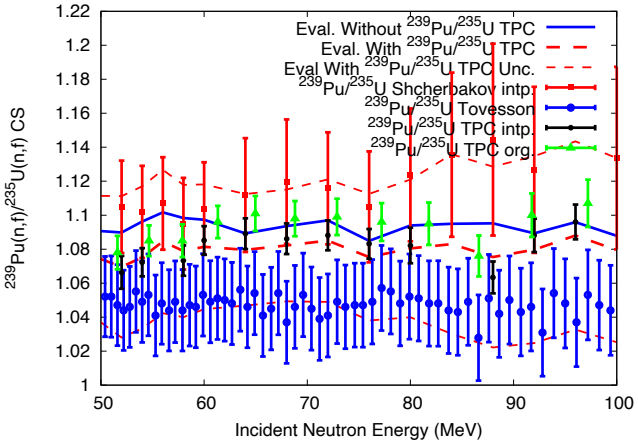






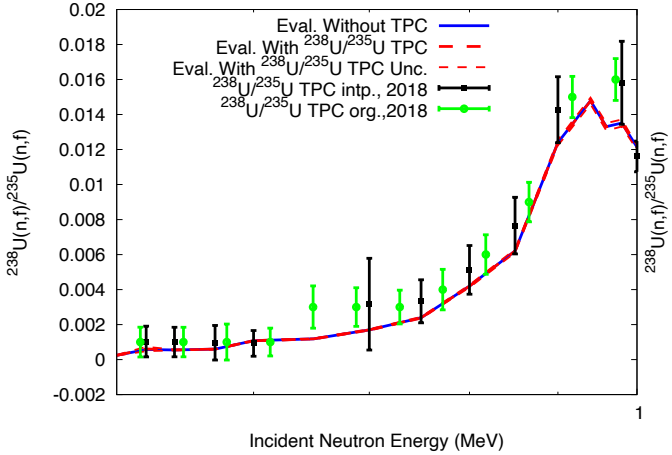


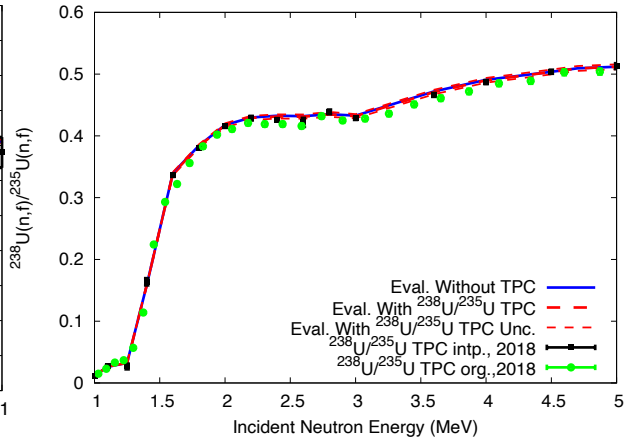


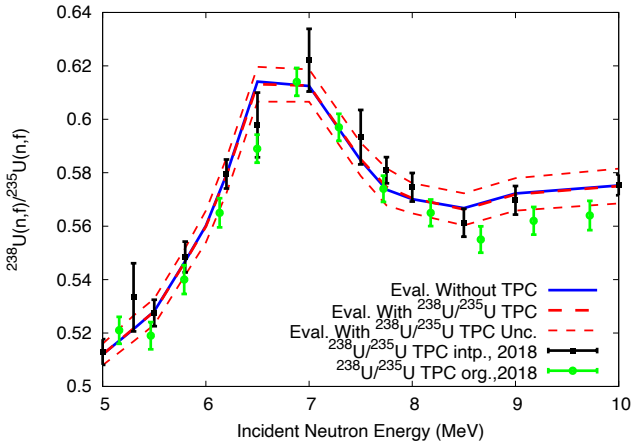


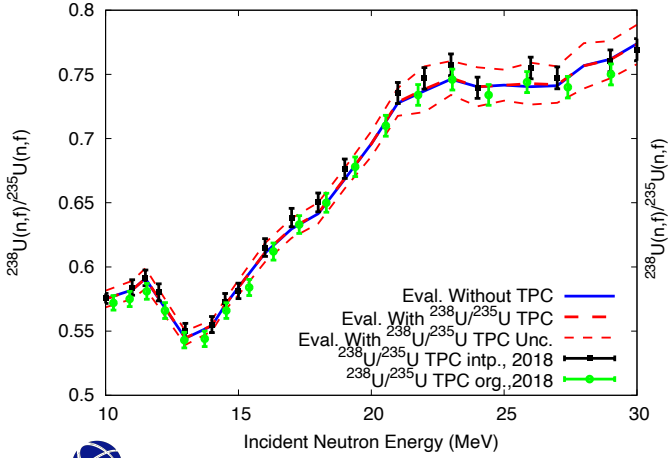
Backup (n,f) cross section nu-bar PFNS

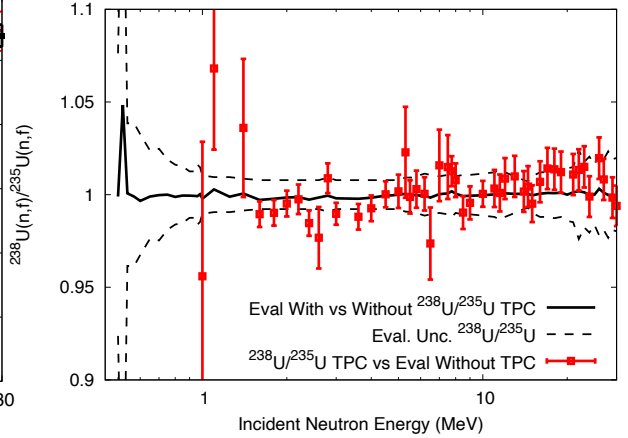
$^{238}U/^{235}U(n,f)$ final niffteTPC data included in standards

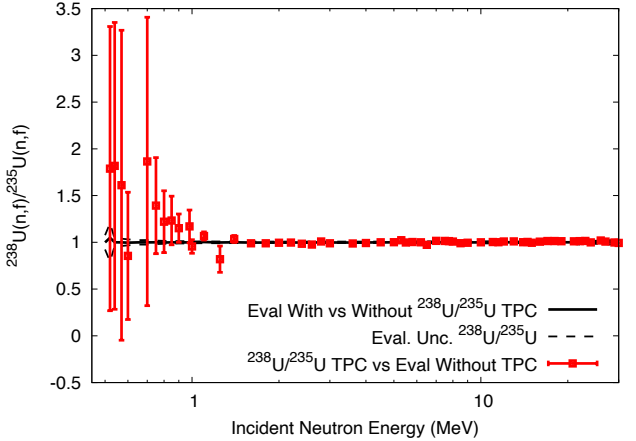






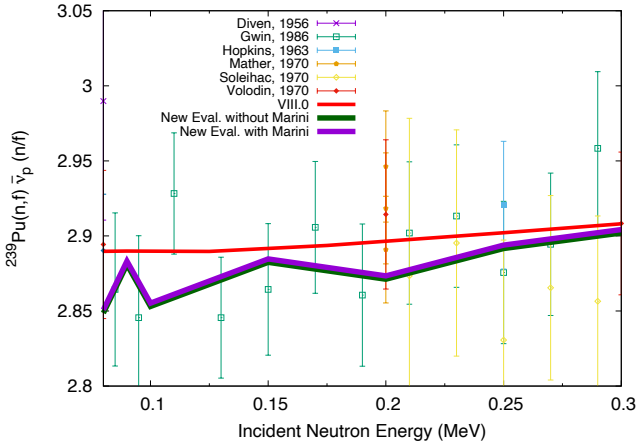


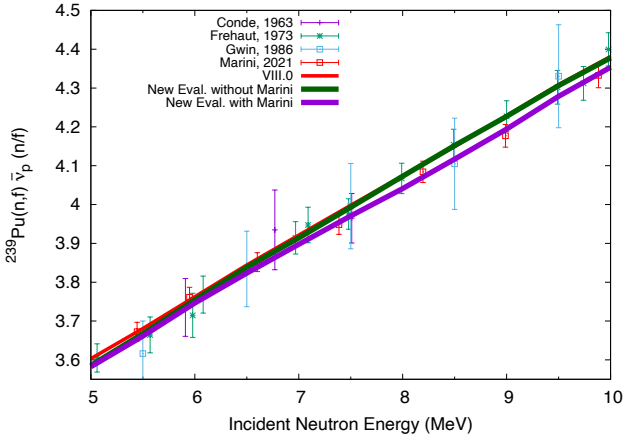


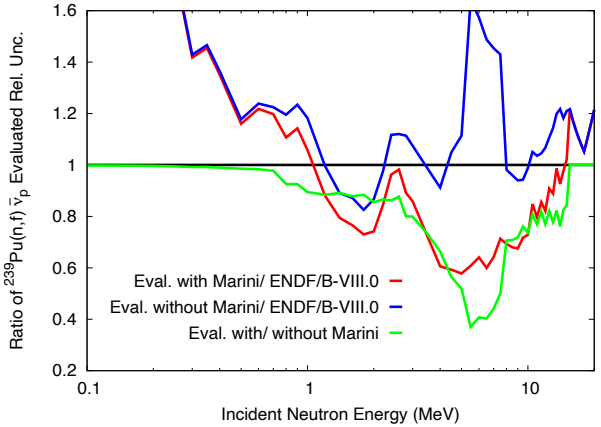


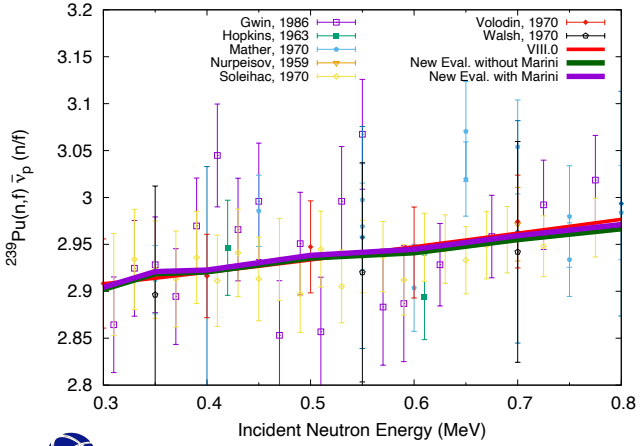
Backup (n,f) cross section nu-bar PFNS

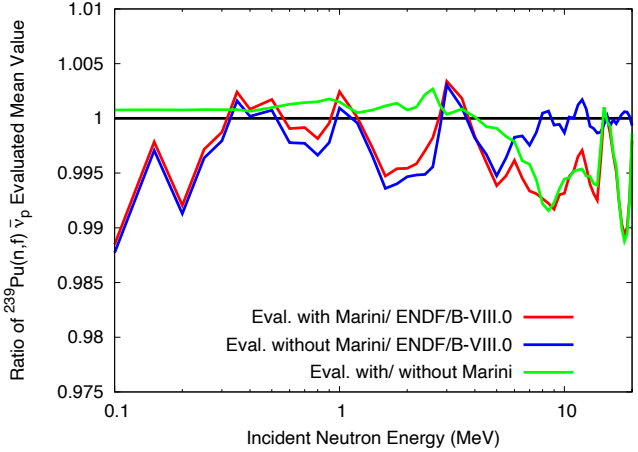
^{239}Pu(n,f) nu-bar data









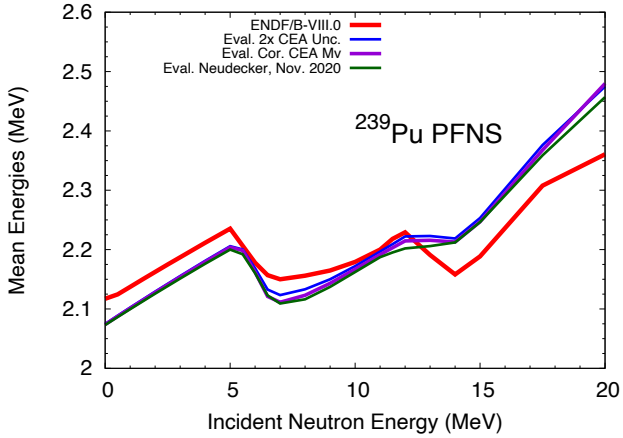


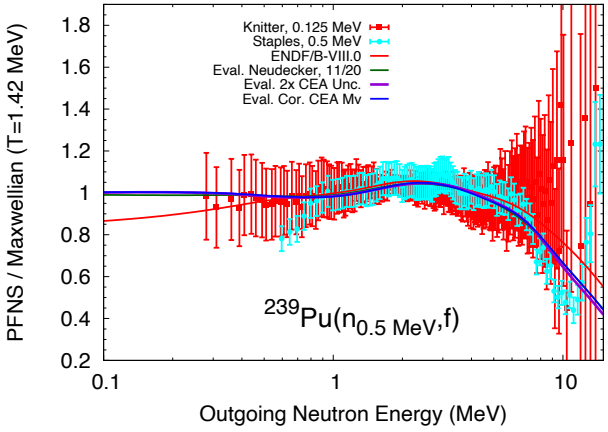
(n,f) cross section

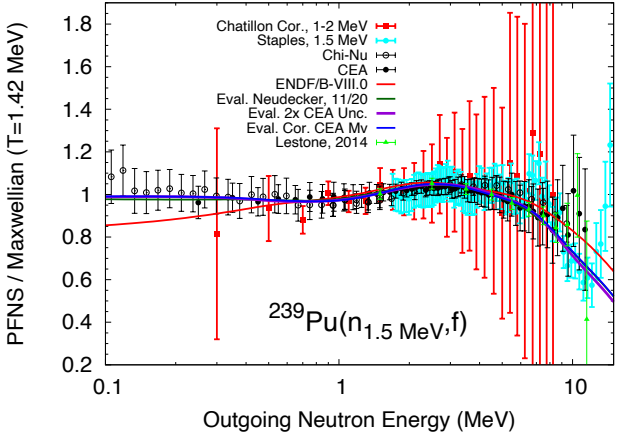
Back-up nu-bar

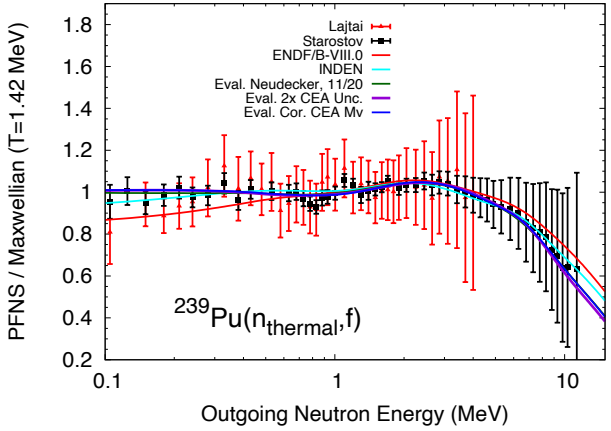
PFNS

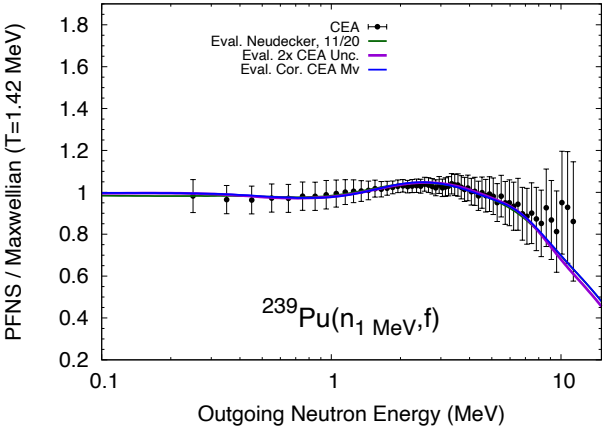
^{239}Pu(n,f) PFNS I

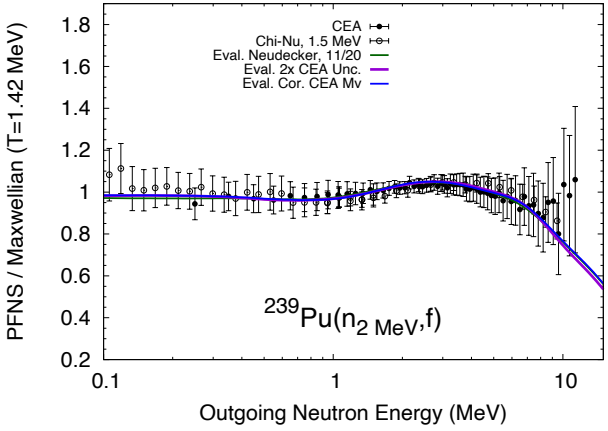










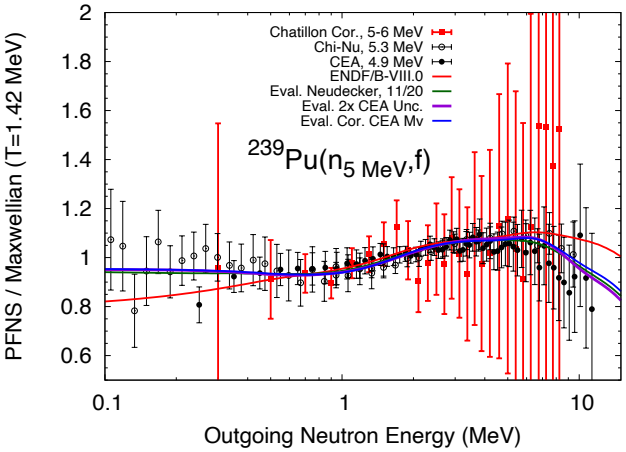


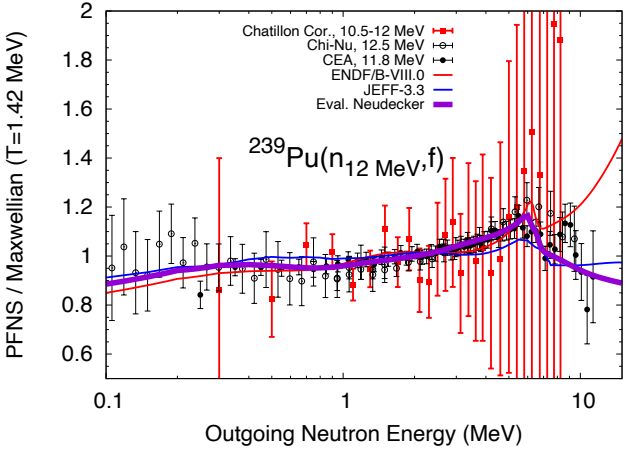
(n,f) cross section

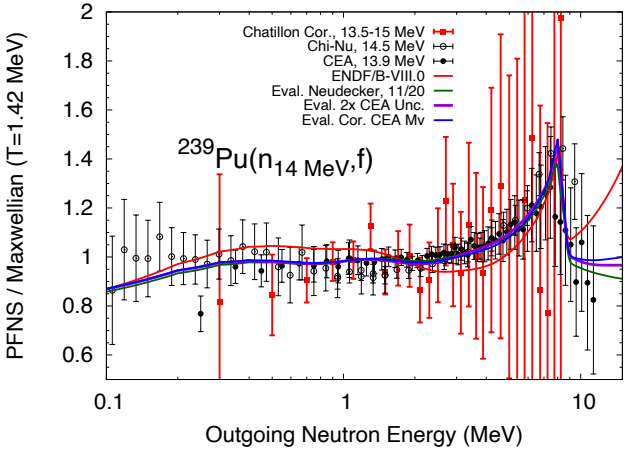
nu-bar

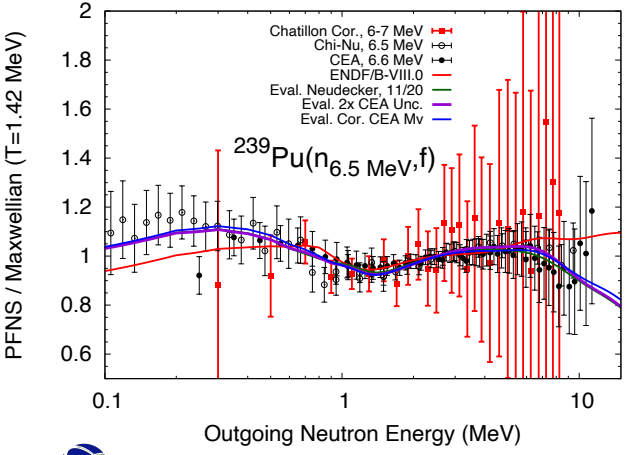
Back-up PFNS

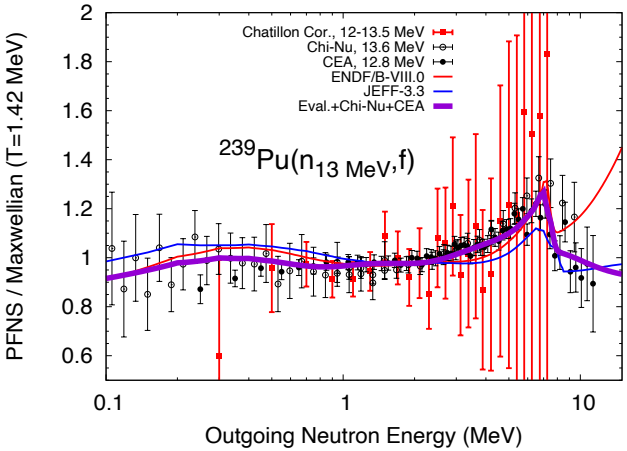
^{239}Pu(n,f) PFNS II

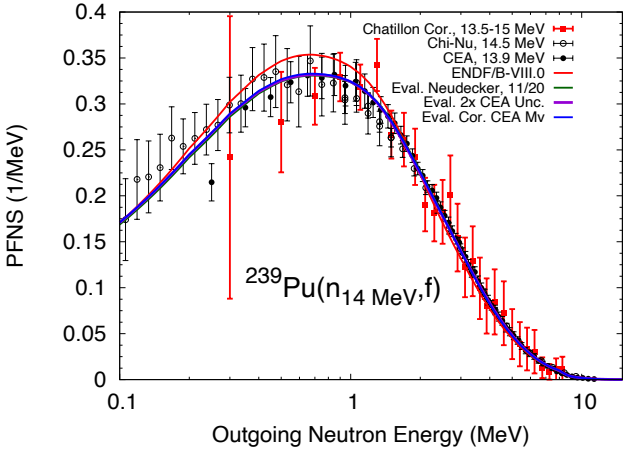












(n,f) cross section

nu-bar

Back-up PFNS