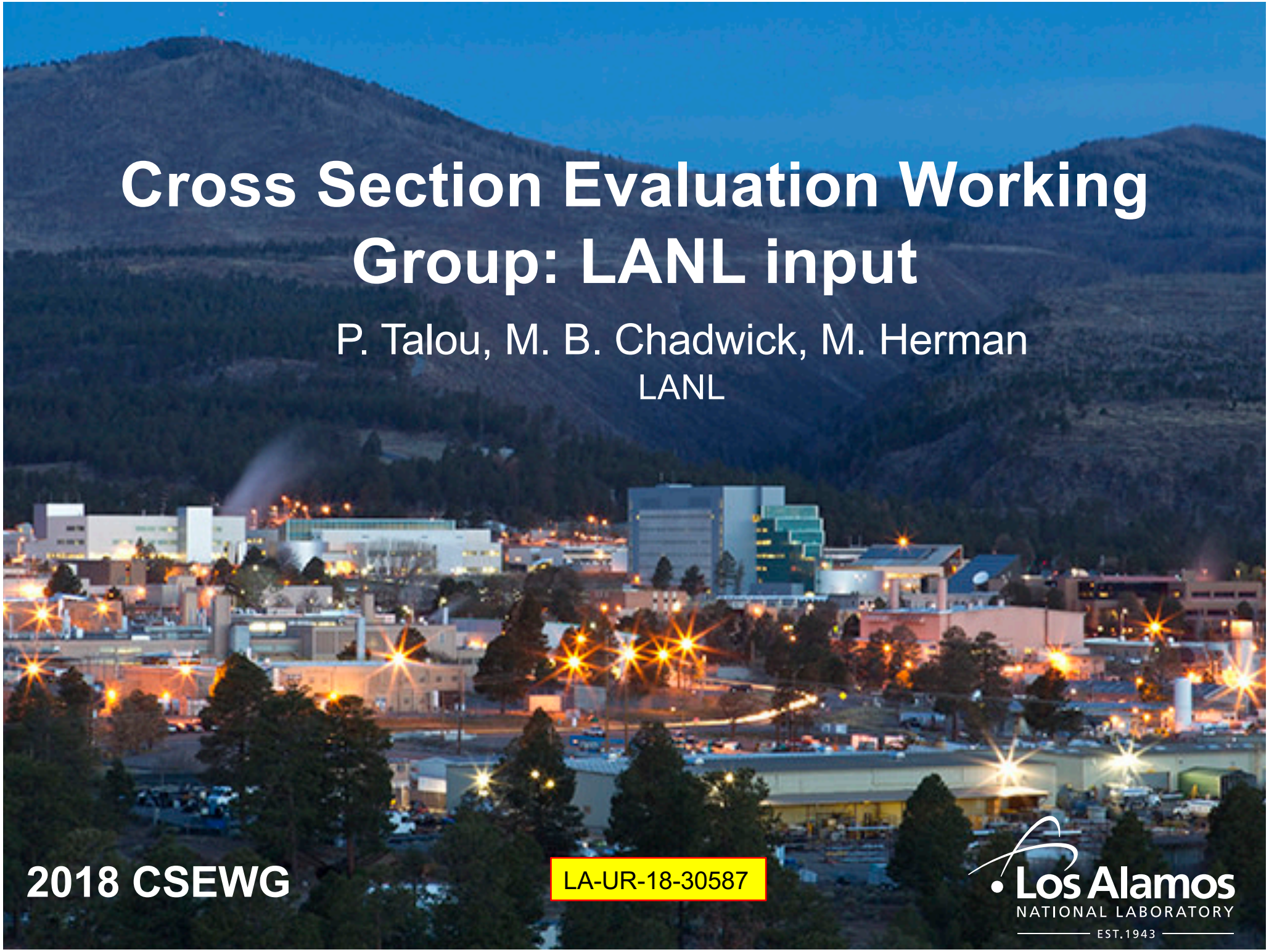


Cross Section Evaluation Working Group: LANL input

P. Talou, M. B. Chadwick, M. Herman
LANL

2018 CSEWG

LA-UR-18-30587

Los Alamos NATIONAL LABORATORY EST.1943

Goals of Evaluation Session

- **Nuclide-by-nuclide summary assessments**

- **Identified one speaker to summarize status, integrating input from multiple labs**
  - Efficiency & time management today
  - Aim to improve cross-lab integration, and integrated planning for future work
  - Terse information will be provided; more details in backups

- **Speakers should focus on gaps**
  - Why is more work needed ?
  - What are the deficiencies? (gaps in experimental / contradictory data / theory?)

- **Typically, POC/speaker for a given nuclide comes from the lab that played a leading role in the last evaluation in ENDF**
  - We recognize that most evaluations are a multi-lab collaboration
  - As we move forward, they should assess and integrate upgrades proposed by other labs

Goals of Evaluation Session

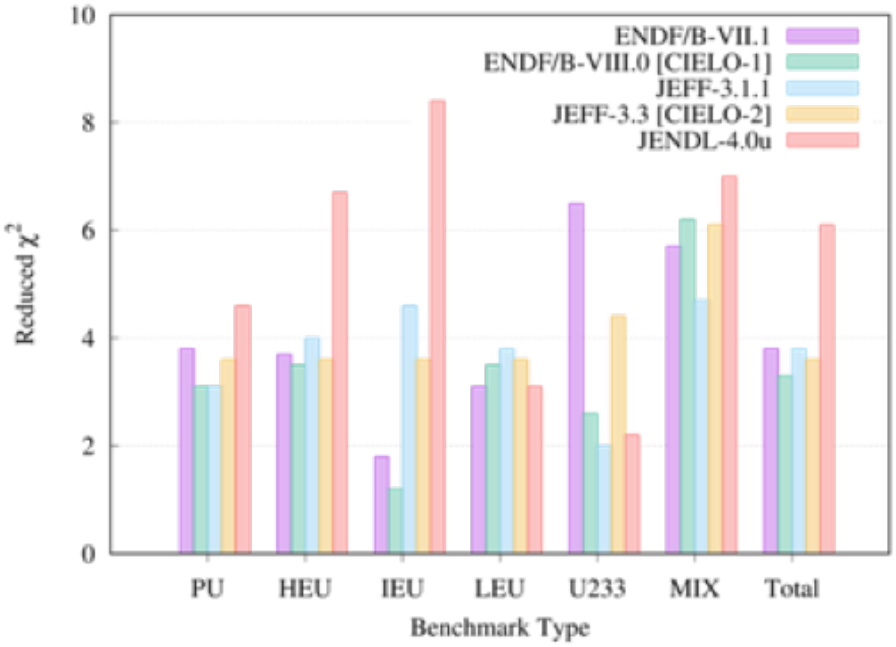
- **Today's work will contribute to subsequent work plans for nuclides in ENDF**

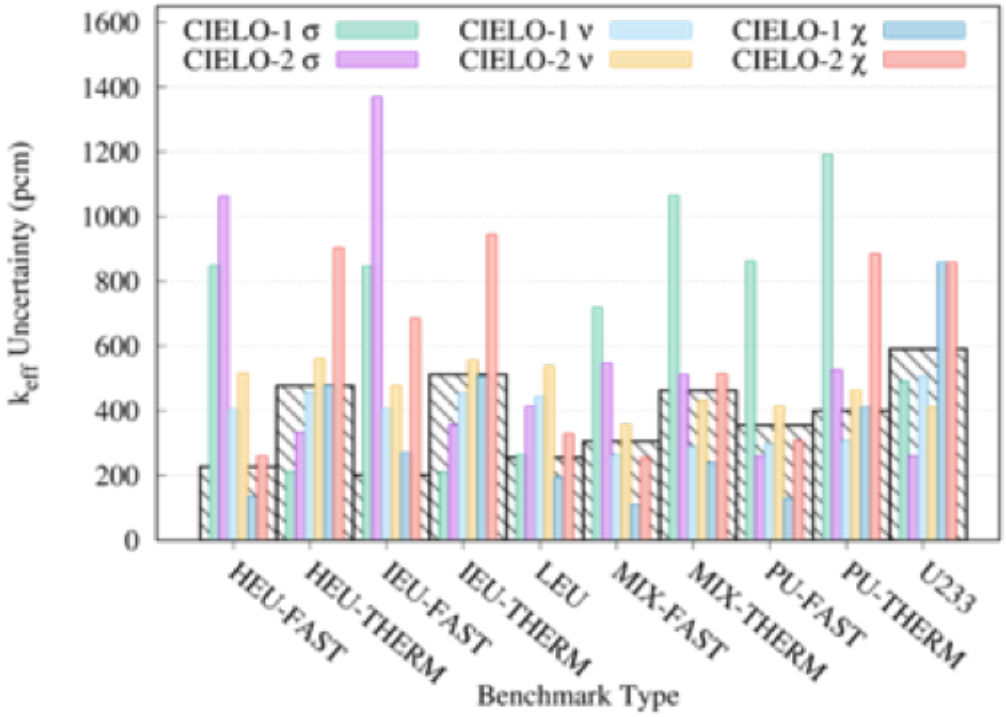
- **Developing new computational tools to support new evaluations**

  - Optimization schemes, machine learning
  - Revision system (git?) to facilitate file management
  - Exploiting new formats, e.g, GNDS
  - Explore consistent use of integral and differential data
    - Including Chadwick's toy model!

We are guided by feedback from users of VIII.0. See Validation Committee

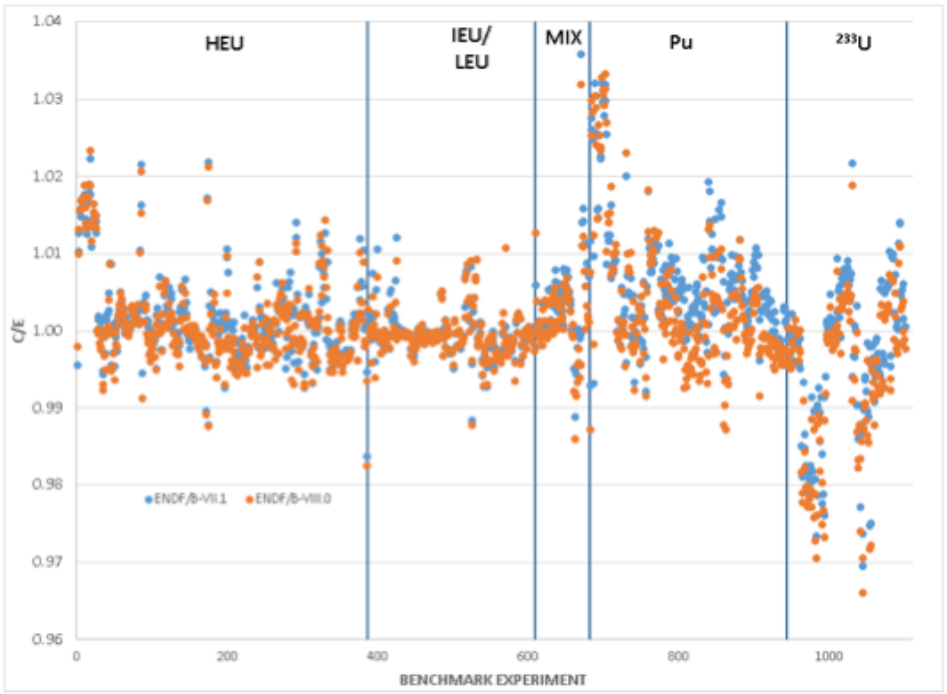
Example: NEA testing, included in CIELO Subgroup 40 OECD document…

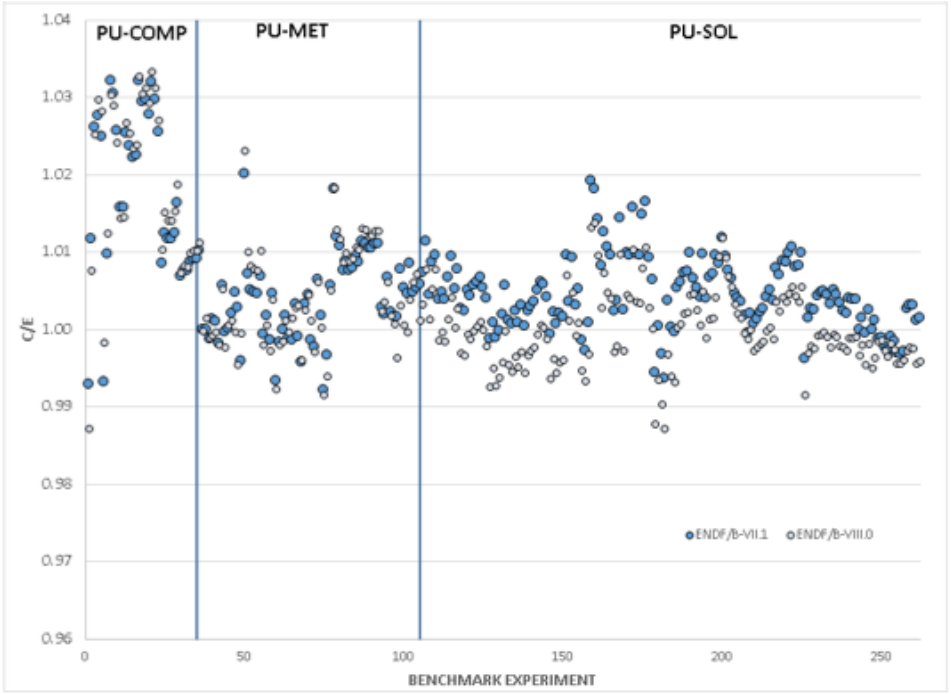




We are guided by feedback from users of VIII.0. See Validation Committee

Example: LANL Criticalit-Safety Whisper benchmark suite (built upon MCNP+ENDF), assesses 7.1 versus 8.0 (Jen Alwin, Forrest Brown) – no surprises





Also, LANL, LLNL & AWE are assessing data in other applications

Plutonium-239 - Status

New information from integral testing since ENDF/B-VIII.0 release & publications

Criticality performance: any new/unexpected findings? ***No – but labs are testing data***

Neutron transmission: any new/unexpected findings? ***No***

(n,xn) activations: any new/unexpected findings? ***Ongoing studies, LANL & LLNL***

Known deficiencies/gaps:

-**Ongoing experiments to precisely measure PFNS and (n,f).** The current set of data (LANSCE expts by LANL, LLNL, CEA) will impact future ENDF. TPC & Chi-nu data now becoming available.

-**Elastic and inelastic scattering** were not changed for ENDF/B-VIII.0; Although we have no information indicating a problem, JEFF and ENDF have very different elastic/inelastic assessments and sensitivity studies point to the importance on k-eff. First RPI-like "semi-integral" scattering experiments have been done at LANSCE and follow-on experiments are planned.

-Thermal ^{239}Pu fission is not consistent with standards(747.4 versus 752.4(2.2)b, *i.e.* just over 2 sigma different). (This choice was motivated by a B-VIII.0 desire not to overpredict thermal solution PST assemblies, a desire that still stands)

- -IAEA thermal PFNS suggested a softer spectrum (E_{av}=2.08 MeV) that was not adopted in B-III.0 (2.11 MeV). Note that
  - -(a) the IAEA thermal PFNS would cause a further over-prediction of PSTs unless compensating changes are found (*e.g.* α increase near 1-2 eV)
  - -(b) PRELIMINARY Chi-Nu trend suggest B-VIII.0 thermal E_{av} may be accurate (also, CEA fast data from LANSCE using a new CEA fiss chamber will provide insights.)

-**An updated ^{239}Pu resonance analysis** – we will follow IAEA-INDEN res. parameter studies.

-**Capture** will be reviewed, in case any changes beyond VIII.0 (used DANCE data) are warranted.

-**(n,2n)** continues to be studied, esp. near threshold – LANL/LLNL studies

-**FPY, DN, Decay energy, PFGS**, would benefit from various upgrades

Plutonium-239 – Plans for next evaluation DRAFT

-**Integrator of next ^{239}Pu ENDF evaluation: LANL**

-Lead for resonance region – ORNL

-Lead for fast region – LANL

-Standards upgrades – IAEA and collaborator labs, notably LLNL lead on TPC 239Pu/235U fission, with LANL collaborating on statistical analysis

-

-**Team will involve…**

-**LANL, LLNL, ORNL, IAEA, CEA, (names TBD)**

-**Objectives of upgrades to include in next evaluation**

-**TBD by team**

- Include LANL & LLNL collaboration with IAEA on optical model scattering options

Plutonium Isotopes

	xs (fast)	xs (RRR)	xs (URR)	PFNS	Nu-bar	Covariances
236	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	31,32,33,34,35
237	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	31,32,33,34,35
238	ENDF/B-VII.1	JENDL-4.0	JENDL-4.0	ENDF/B-VII.1	ENDF/B-VII.1	31,33,35
239	ENDF/B-VIII	ENDF/B-VIII	ENDF/B-VIII	ENDF/B-VIII	ENDF/B-VIII	31,32,33,35
240	ENDF/B-VII.1	ENDF/B-VIII	ENDF/B-VII.1	ENDF/B-VII.1	ENDF/B-VII.1	31,32,33,35
241	ENDF/B-VI	ENDF/B-VI	ENDF/B-VI	ENDF/B-VI	ENDF/B-VI	ENDF/B-VII
242	JENDL-4.0	ENDF/B-VII	ENDF/B-VII	JENDL-4.0	JENDL-4.0	31,33,34,35
243	ENDF/B-V-VI	ENDF/B-V-VI	ENDF/B-V-VI	ENDF/B-V-VI	ENDF/B-VIII	
244	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	ENDF/B-VIII	31,32,33,34,35
245	ENDF/B-VIII?	ENDF/B-VIII?	ENDF/B-VIII?	From Pu243	From Pu243	
246	JENDL-4.0	JENDL-4.0	JENDL-4.0	JENDL-4.0	ENDF/B-VIII	31,33,34,35

ENDF/B-VIII.0
Older ENDF/B
Recent, OK
Needs work
Bad
Nothing
Other evaluation

Note: some details of evaluation mods not visible from this summary table.

Consistent Suite of Pu isotopes

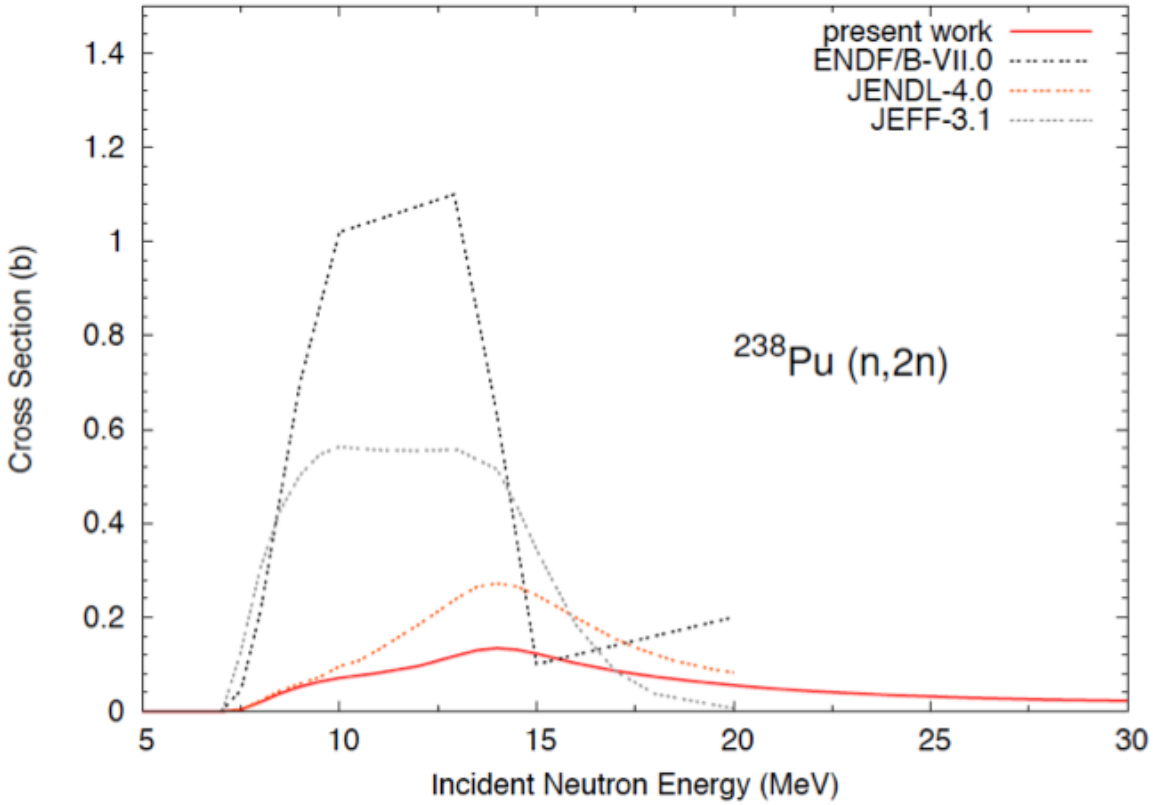
- Cross Sections, energy spectra, angular distributions
  - CoH3 calculations, global parameter optimization
  - Fission cross section across suite of isotopes, considering multi-chance fission constraints
  - Elastic/inelastic scattering
  - New experimental data: capture (Mosby, 2018); fission (TPC); others?
- Fission Data
  - PFNS: Chi-Nu data + new evaluation using CGMF/BeoH calculations
  - Nu-bar: Revisit evaluation / data sets
  - Energy release: updates with TKE vs. Einc
  - PFGS: new CGMF calculations for multiplicity-dependent spectra; DANCE data?
- Delayed neutrons?
- FPY: work under NA22 – mostly 239Pu; also use of fissionTPC for (A,TKE) distributions?
- Updates on RRR
  - ORNL? Others?
- Benchmarks: k_{eff}, Pulsed-Spheres, RPI-type benchmarks
- Use of ENDF and GNDS formats
- Covariances: revisit low-fidelity estimates, use eigenvalue decomposition instead? Propagation of uncertainties in benchmarks.

Consistent Suite of Pu isotopes: who?

- LANL - integrator
  - Kawano, Mumpower, Stetcu, Neudecker, Talou
  - LANSCE experimentalists: Kelly, Devlin, Mosby, Couture
  - Benchmarks: Neudecker, Haeck, White
- Collaborations:
  - LLNL:
    - Who? Quaglioni, Thompson, Ormand, Hoffman, Mattoon, …
    - What? fissionTPC, surrogate, GNDS, benchmarks, …
  - IAEA:
    - Standards, consistency with 235,238U evaluations, PFNS, benchmarks
  - ORNL:
    - Resolved resonance region; new efforts?
    - URR?
  - CEA?

Plutonium-238 - Status

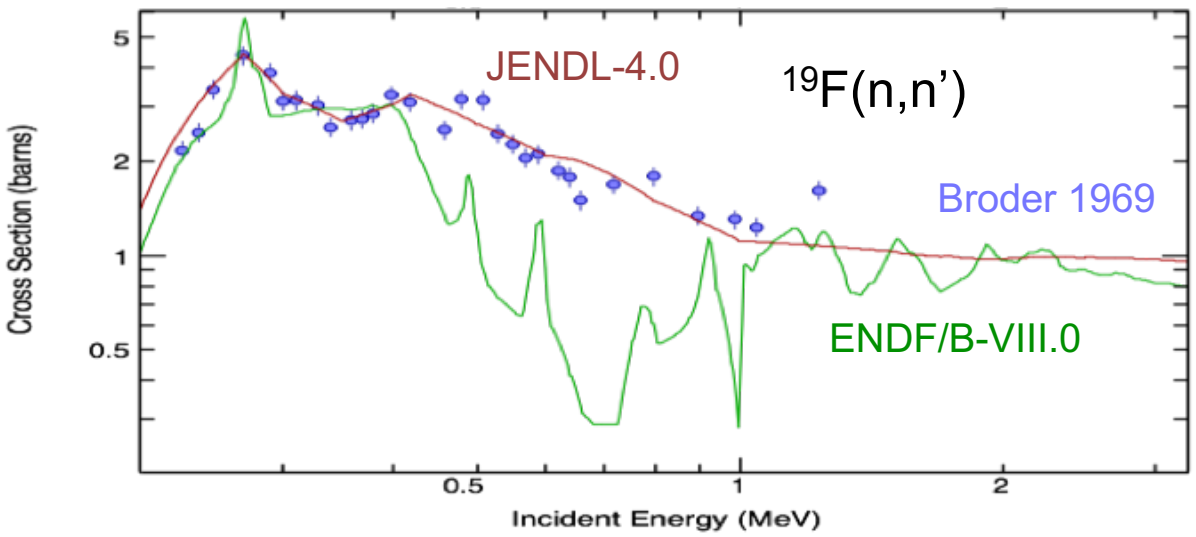
Revisit the 238Pu(n,2n)

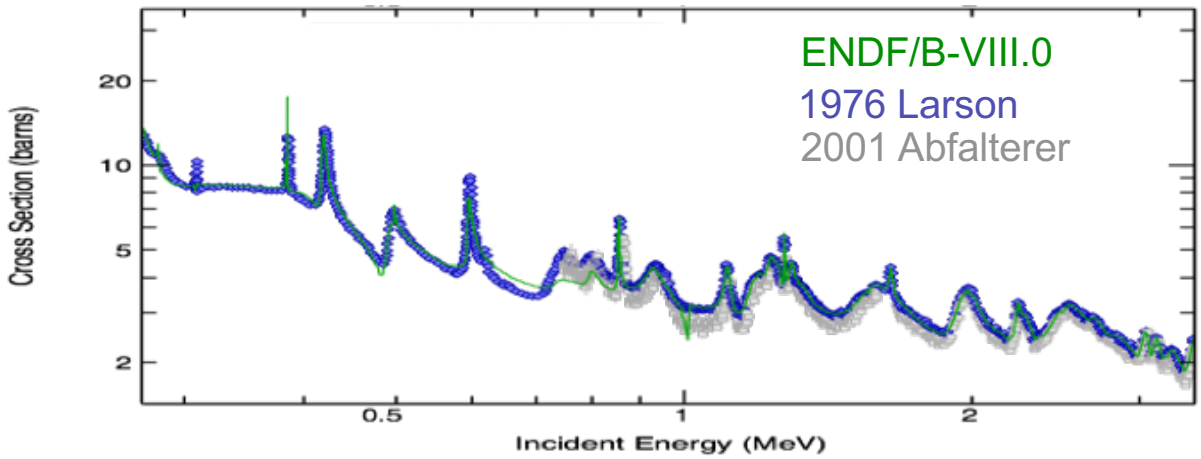


Americium-241 - Status

The thermal 241Am cross section needs to be increased to a bit over 700b, per conclusions from the NEA/WPEC subgroup conclusions

Status of 19F

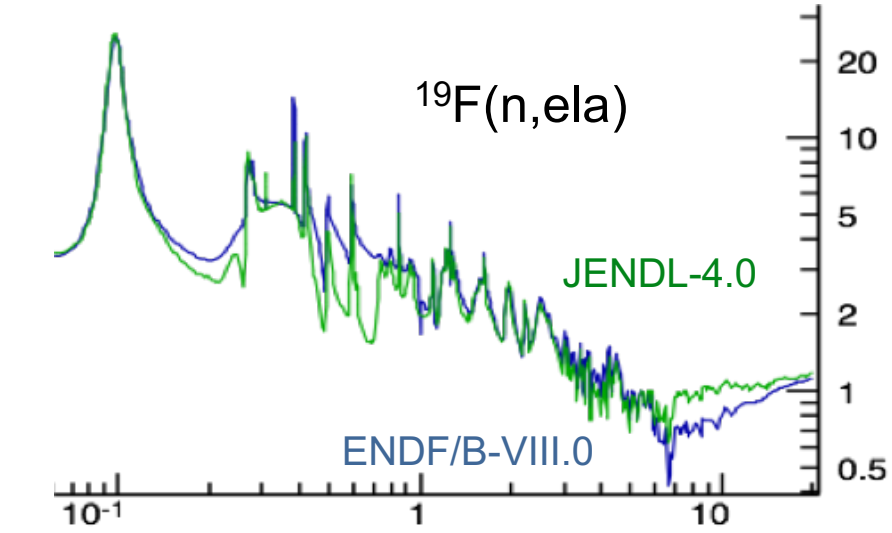


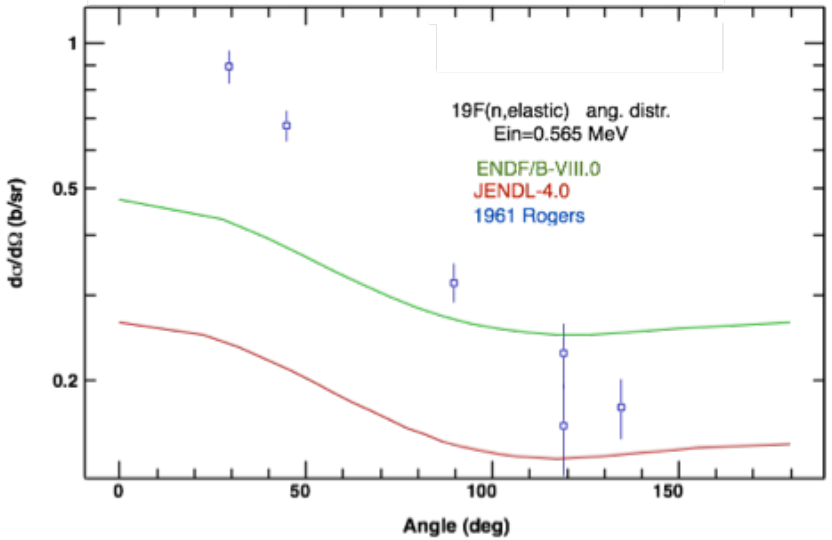


Known deficiencies:

- *ML exercise pointed to ^{19}F as main cause bias in ^{233}U solution benchmarks*
- *Inelastic seems too low <1 MeV (elastic too high)*
- *Shape of total could be improved (0.6-0.9 MeV)*
- *Total might be too high*
- *RR extends to1 MeV (JENDL-4.0 up to 0.1 MeV)*
- *No RR parameters given*
- *Elastic ang. distr. in RR too flat (o.m.p.)*

Status of 19F

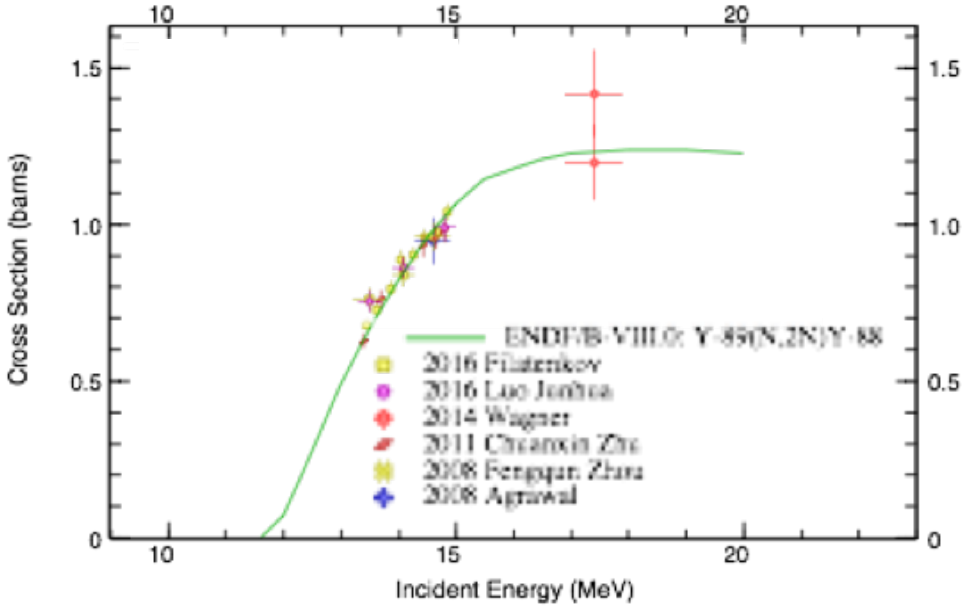


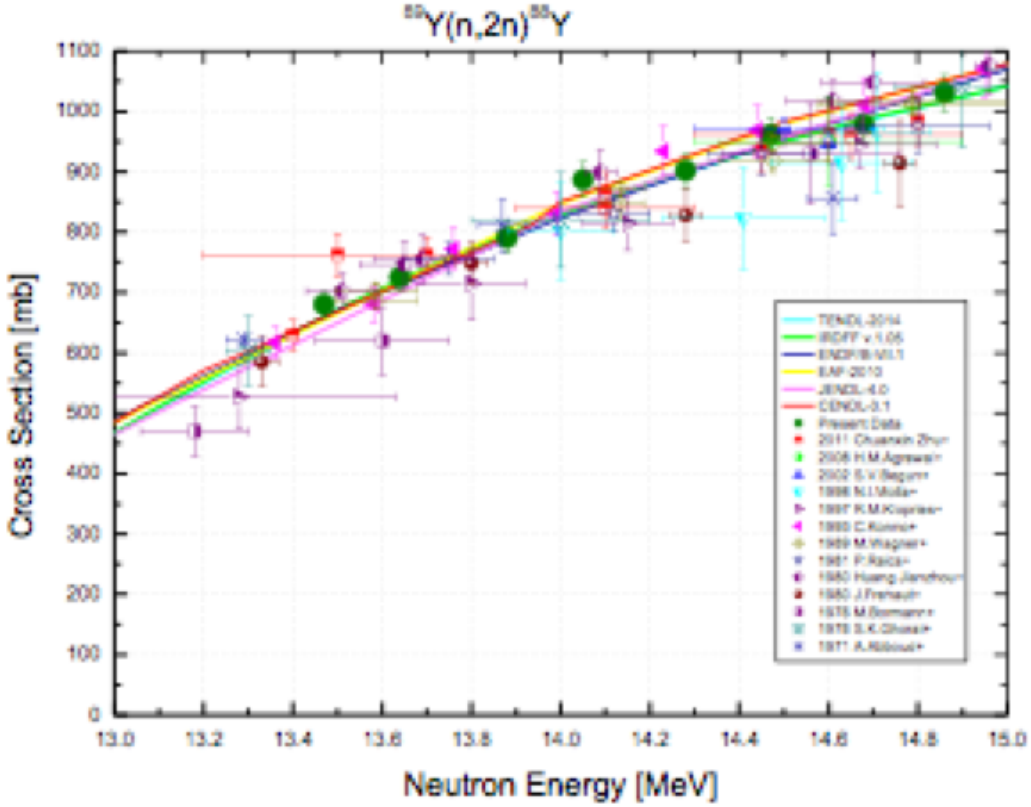


Recommendations:

- *Re-evaluate taking into account:*
  - *assessment of missing resonances*
  - *providing RR parameters*
  - *using RR ang. distr. for elastic*
  - *improving shape of total*
  - *reconsidering elastic - inelastic split*
  - *renormalization of total to Abfalterer*

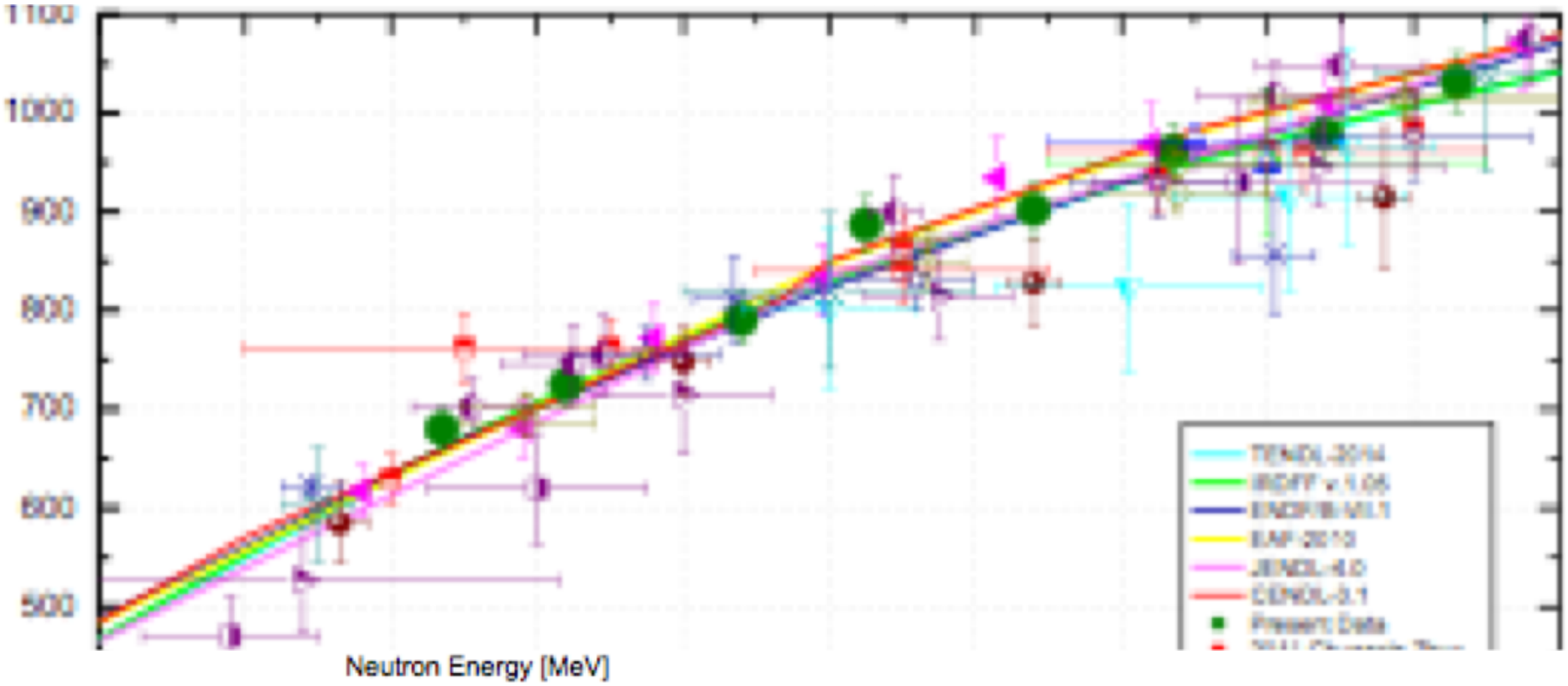
Status of ^{89}Y: (n,2n)





Excellent agreement between 6 new measurements and ENDF/B-VIII.0

Status of ^{89}Y: (n,2n)



Excellent agreement between Filatenkov and ENDF/B-VIII.0

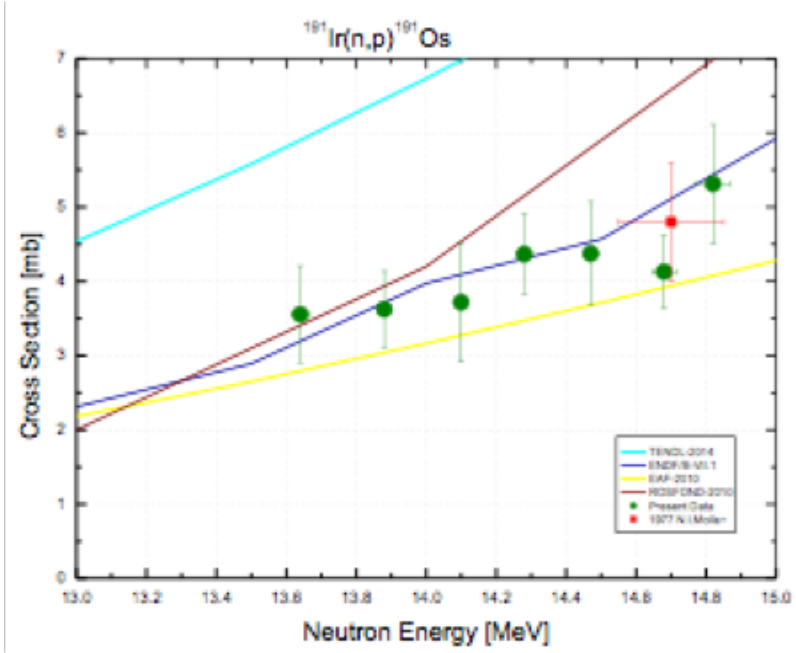
^{89}Y Discussion and Recommendations

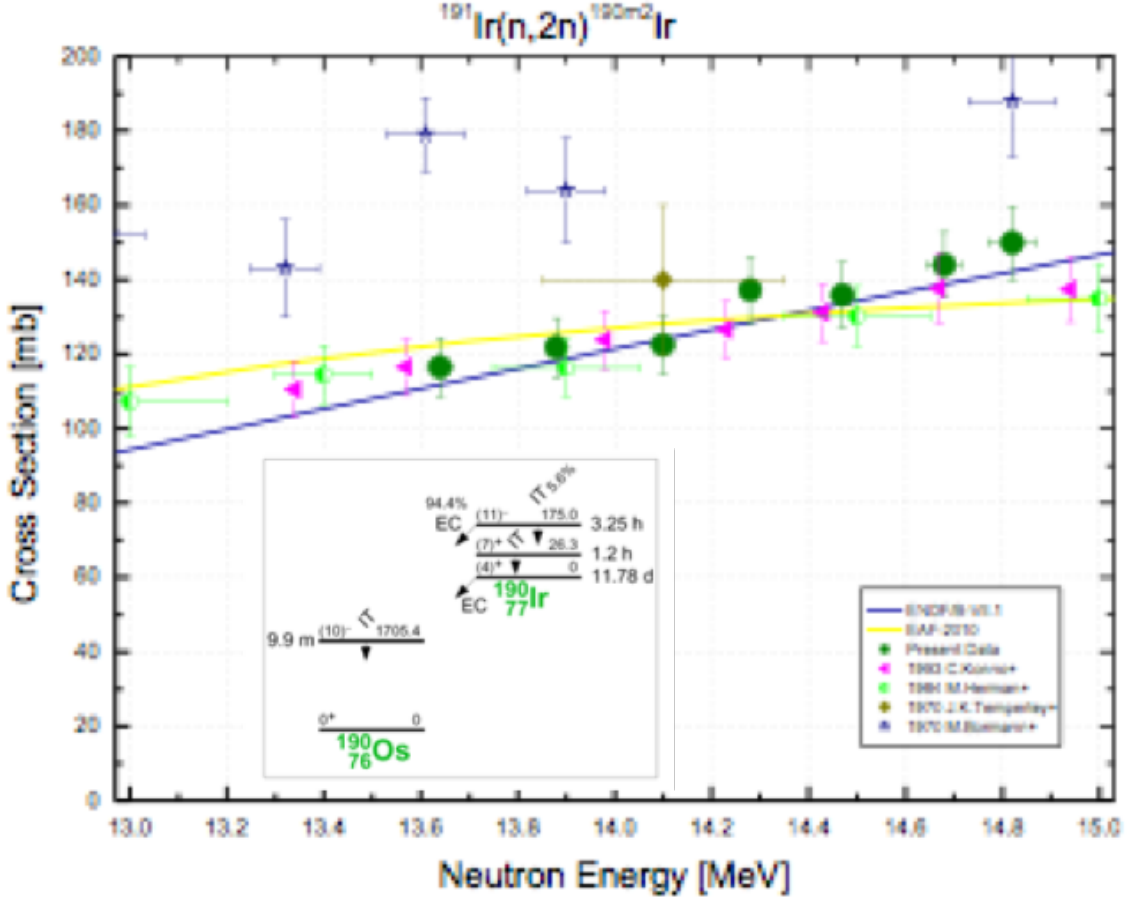
- Two isomeric (n,2n) x-sec. of primary importance
- New measurements confirm ENDF/B-VIII.0
- There is no expectation to improve tight uncertainties reported in the LANL paper
- Covariances only for the total (n,2n) x-sec. not for the two isomers
- numerous indications of format problems

Reevaluation would be beneficial for overall consistency but radchem reactions wouldn't be affected. There are no measurements for ^{90,91}Y.

Status of ^{191}Ir

New experiments (Konno 1993 & Filatenkov 2016) agree perfectly for (n,2n)m2 and (n,p)



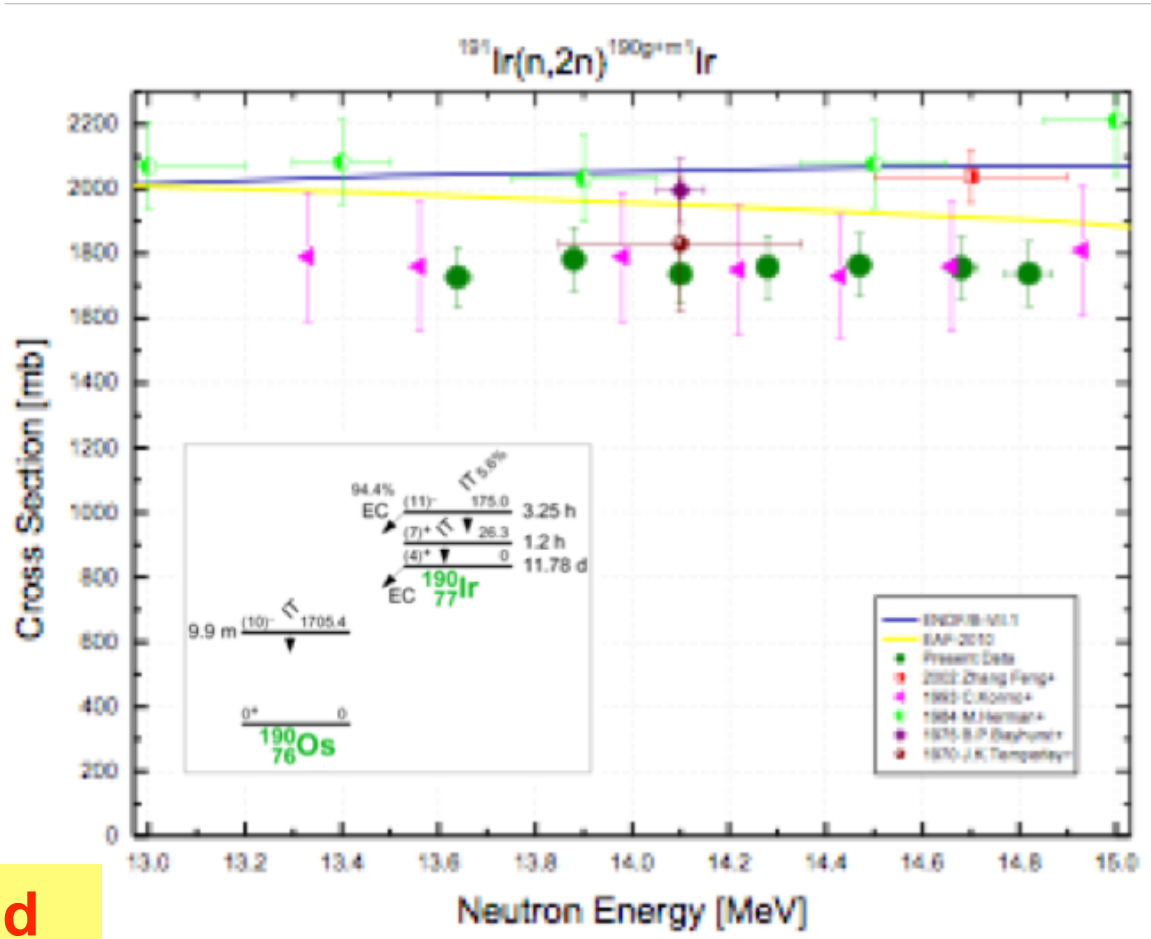


^{191}Ir(n, 2n)$^{190g+m1}$Ir

Known deficiencies:

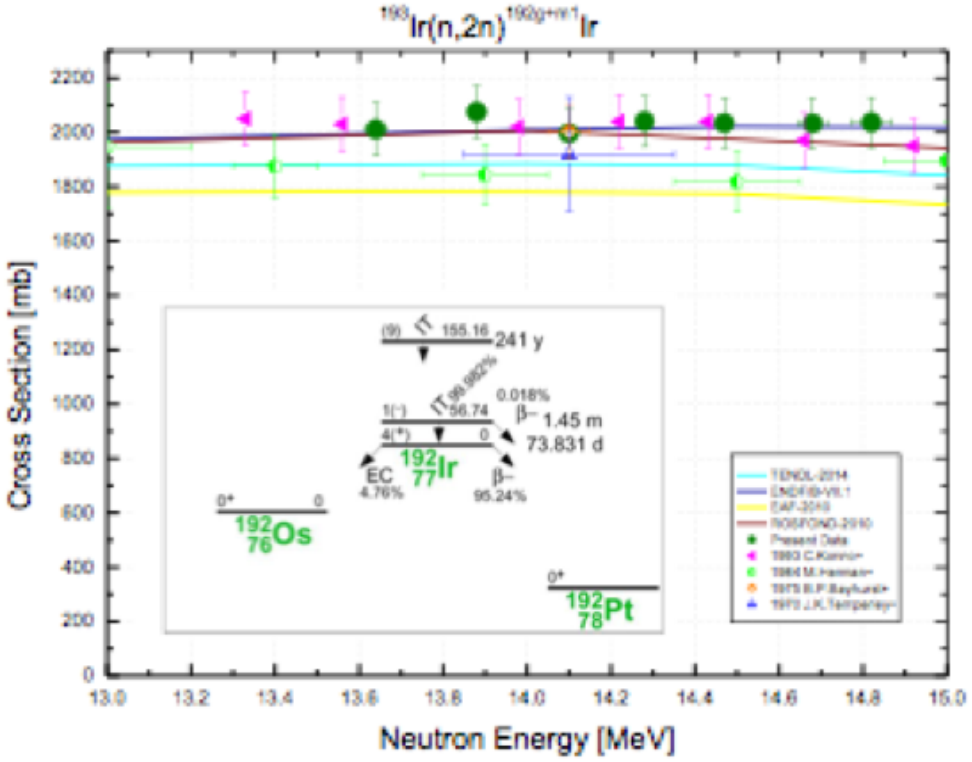
… but the same two new measurements are lower by ~300 mb for (n,2n)g+m1

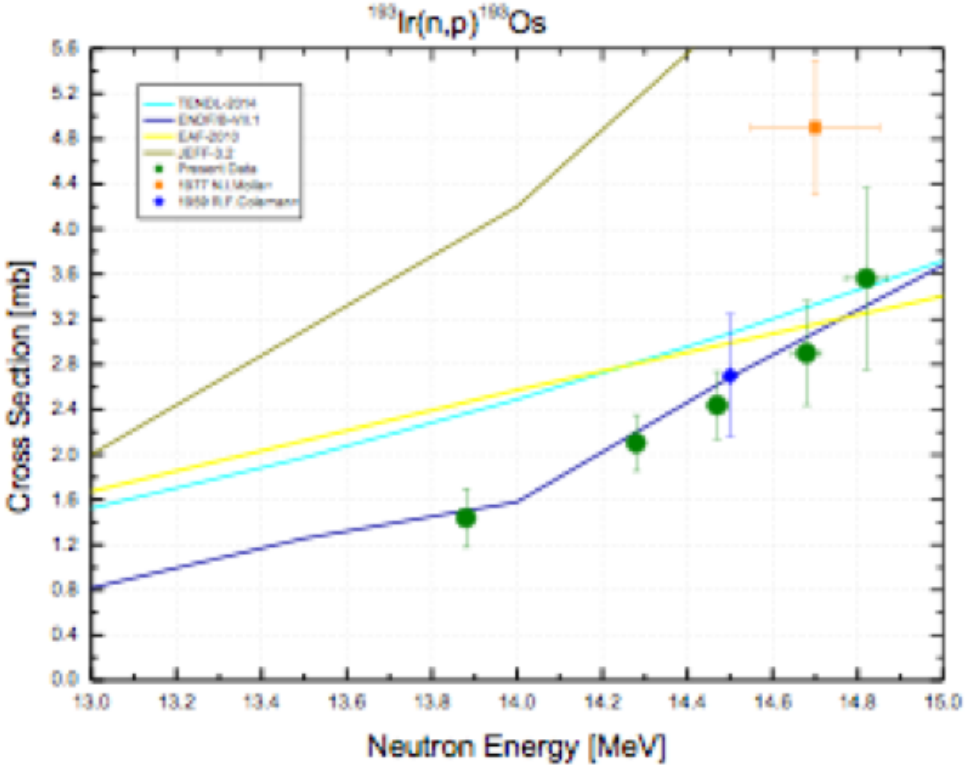
Filatenkov's experiment is very carefully done & well documented in INDC(CCP)-0460. It supports ^{191}Ir(n,2n)m2.



^{191}Ir should be reevaluated

Status of ^{193}Ir

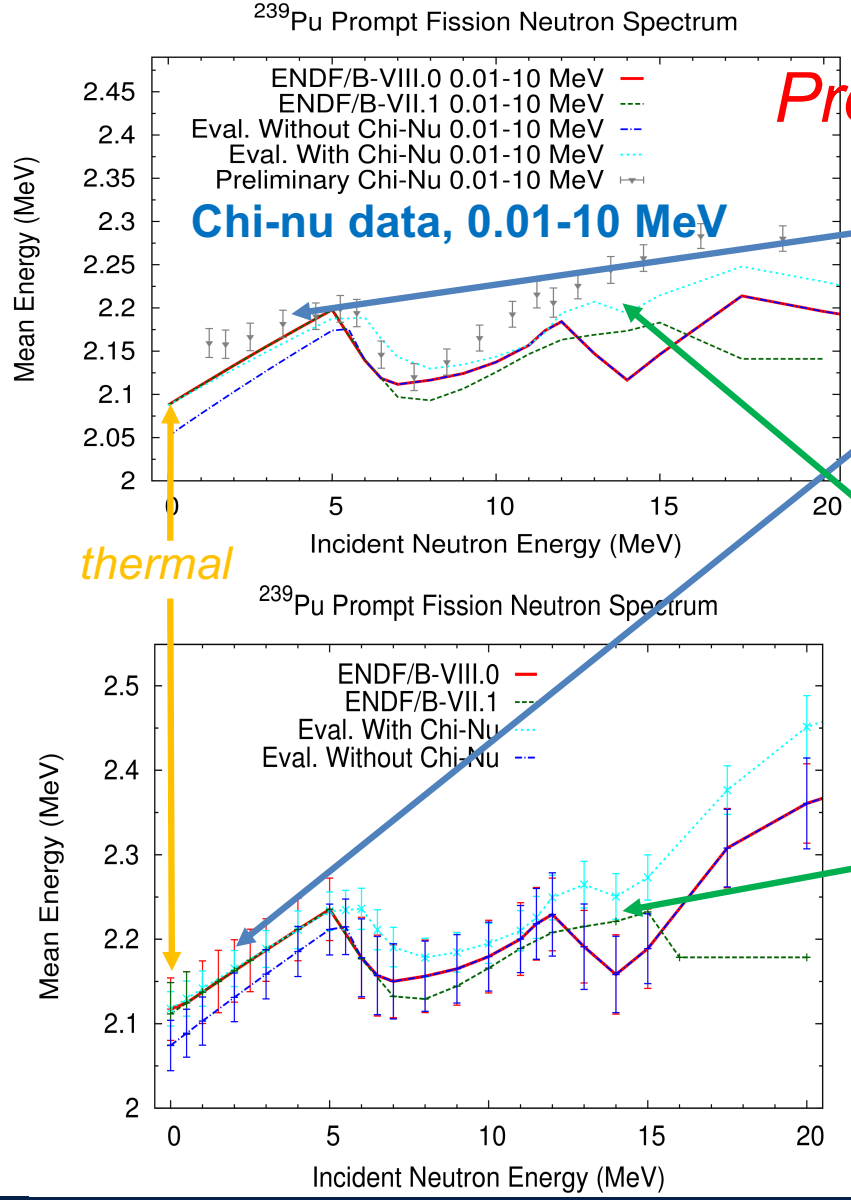




Konno and Filatenkov support all E8.0 activation x-sec. on ^{193}Ir.

Backup – more information

PFNS : ongoing work to assess impact of ^{239}Pu Chi-nu on future PFNS evaluation



Preliminary

Chi-nu data:

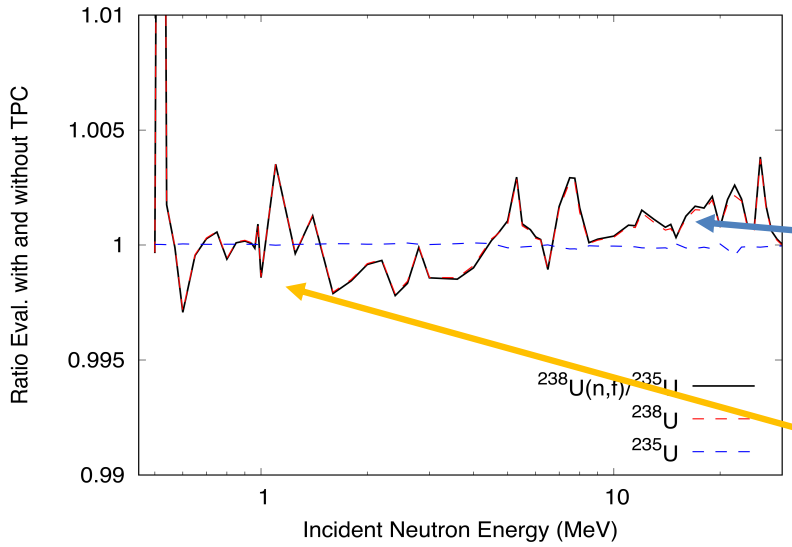
-Support Eav in current ENDF/B-VIII.0 in the fast region (<5 MeV)

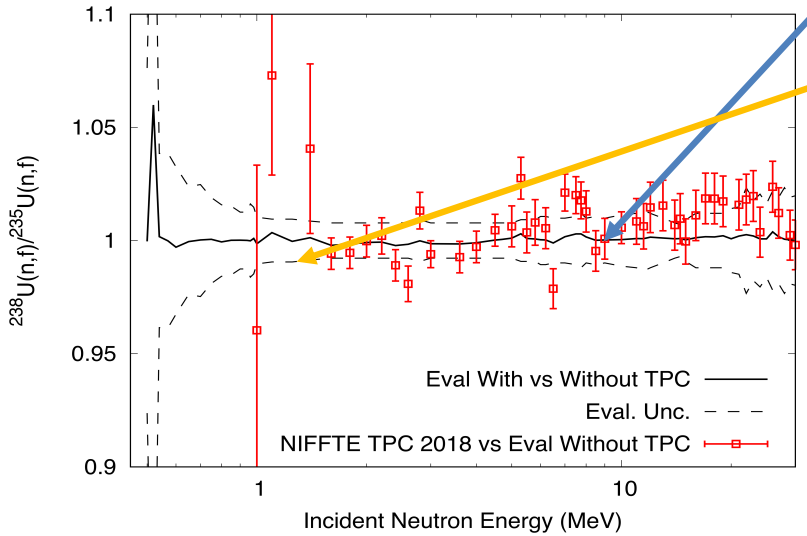
-Although not measured at thermal, Chi-nu data from 1-5 MeV inc. energy, combined with models, supports B-VIII.0 & suggests leaving B-VIII.0 thermal PFNS Eav until future data compellingly points to an alternative (i.e., do not yet adopt IAEA 2017 thermal ^{239}Pu PFNS which has thermal Eav~2.08, versus 2.11 MeV)

-At 14 MeV (and down to 5 MeV) Chi-nu points to a hotter spectrum for a future evaluation, and does not see as strong an impact of 3rd chance fission.

Neudecker working with LANL-LLNL Chi-nu team; this will impact future ENDF upgrades

Fission cross section: recent impact of $^{238}U/^{235}U$ TPC data on $^{238}U(n,f)$





TPC preliminary data is in fair agreement with the existing 2018 standards, though:

-Above 5 MeV, TPC higher and increases the evaluated $^{238}U(n,f)$ cross section, *by factions of a percent*

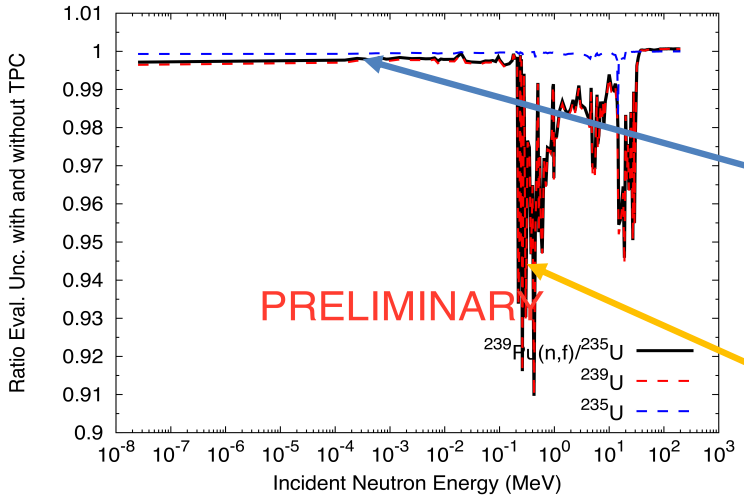
-Below 5 MeV, TPC values change the evaluated $^{238}U(n,f)$ cross section, lower and higher (depending on energy) *by fractions of a percent*

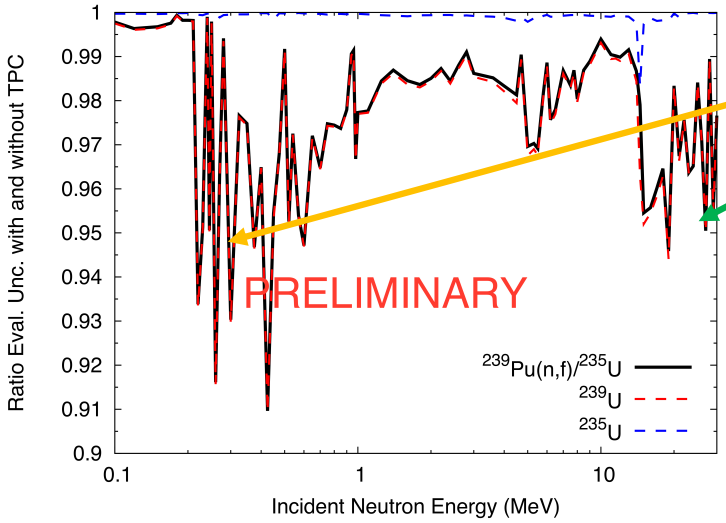
-Relevance for $^{239}Pu(n,f)$, TPC $^{239}Pu(n,f)$ data are expected to be more precise and absolute data → larger impact on $^{239}Pu(n,f)$ standards evaluation expected.

Neudecker working with LLNL-LANL TPC team; this will impact future IAEA standards upgrades

Fission cross section: ongoing work to assess impact of TPC NIFFTE ^{239}Pu/^{235}U data on (n,f)

Preliminary





Preliminary TPC ^{239}Pu(n,f)/^{235}U(n,f) data lead to decreased uncertainties if included in the 2018 standards:

-All inc. energies: TPC ^{239}Pu(n,f) data lead to decreased evaluated unc. for all E_{inc} as data are absolute ratios.

-Below 1 MeV, TPC data lead to eval. ^{239}Pu(n,f) unc. decreased by 9%

-At 14 MeV and higher TPC data might help resolve question concerning discrepant data (Tovesson, Staples, Lisowski, Scherbakov)

Final TPC unc. are expected to be of similar size. Similar impact on evaluated unc. can be expected.

Comment: no USU unc. included!

Neudecker working with LLNL-LANL TPC team; this will impact future IAEA standards upgrades