Status report on NRG activities

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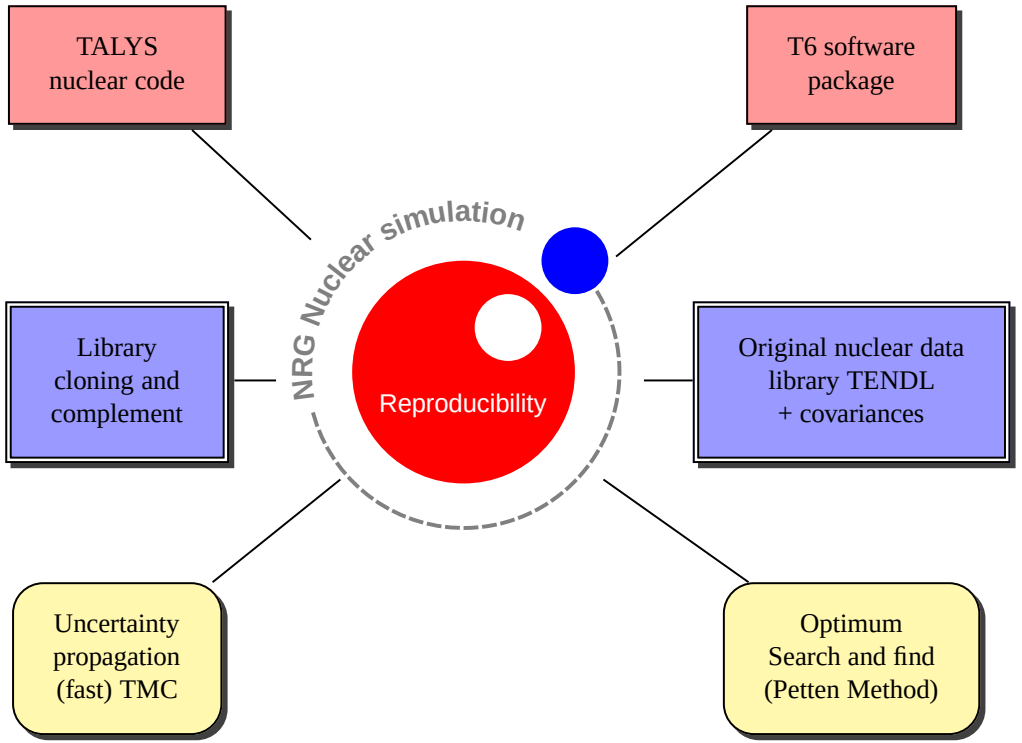


Task 6.2

Objective: to generate a consistent TENDL based general purpose/activation sub-library for Fe, Cr, W, Mn Ta, V, Mn (major Eurofer constituents) and demonstrate/prove consistency of the produced data with EAF data for activation and JEFF data for neutron transport.

Activities:

1. Report on TENDL's unification methodologies and format, and processing aspects (NRG & CCFE),
2. Generation and delivery of unified TENDL-2011 base library (NRG & CCFE),
3. Processing and delivery of applications libraries for transport and activation from TENDL-2011 neutron library (CCFE).
4. V& V: of modelling capabilities on the Eurofer constituents Fe, Cr, W, Ta, V, Mn including differential excitation function comparisons (NRG)

Last activity: report to be delivered by the end of 2013.

Background: TENDL-2011/2012 (www.talys.eu/tendl-2012)

- Collaboration between NRG, CCFE, JUKO Research, Uppsala University, IAEA/NDS, CEA Bruyeres-le-Châtel and Vattenfall
- Neutrons: 2435 ENDF files (200 MeV, MF1-15 and MF31-40), plots, ACE, EAF, processed files
- Based on TALYS + automatic normalization, or *autonorming*, see next slides
- Imported files: ^{1,2,3}H, ^{3,4}He, ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{nat}C, ^{14,15}N, ^{16}O, ^{19}F, ^{235,238}U, ^{239}Pu

- Default: Global calculations by TALYS-1.48 and TARES (resonances) which are overruled by
- Adjusted TALYS calculations (340 input files) and Resonance Atlas-based TARES calculations which are overruled by
- TALYS-normalization to 200 (experimental) evaluated reaction channels from other libraries (e.g. EAF, IRDFF, light nuclides, main channels of the big 3)

Importing other cross sections: *autonorming*

The *autonorming* capability of the TALYS system is a key functionality in this project. It was first tested in TENDL-2009 and was thereafter further developed and improved. The principle is rather simple: if a cross section is better evaluated in another library, it should be possible to ”import” it for the TENDL evaluations, without manual interventions, and following a few rules:

- read the original cross section with its energy grid,
- import it in the TENDL evaluation (replacing the existing TALYS cross section),
- expand or simply adjust the energy grid to match the TENDL lower and higher limits,
- respect the sum rules (modifying one or more of the total, elastic and non elastic cross sections),
- keep the possibility to obtain random cross sections for the TMC uncertainty propagation.

Importing other cross sections: *autonorming*

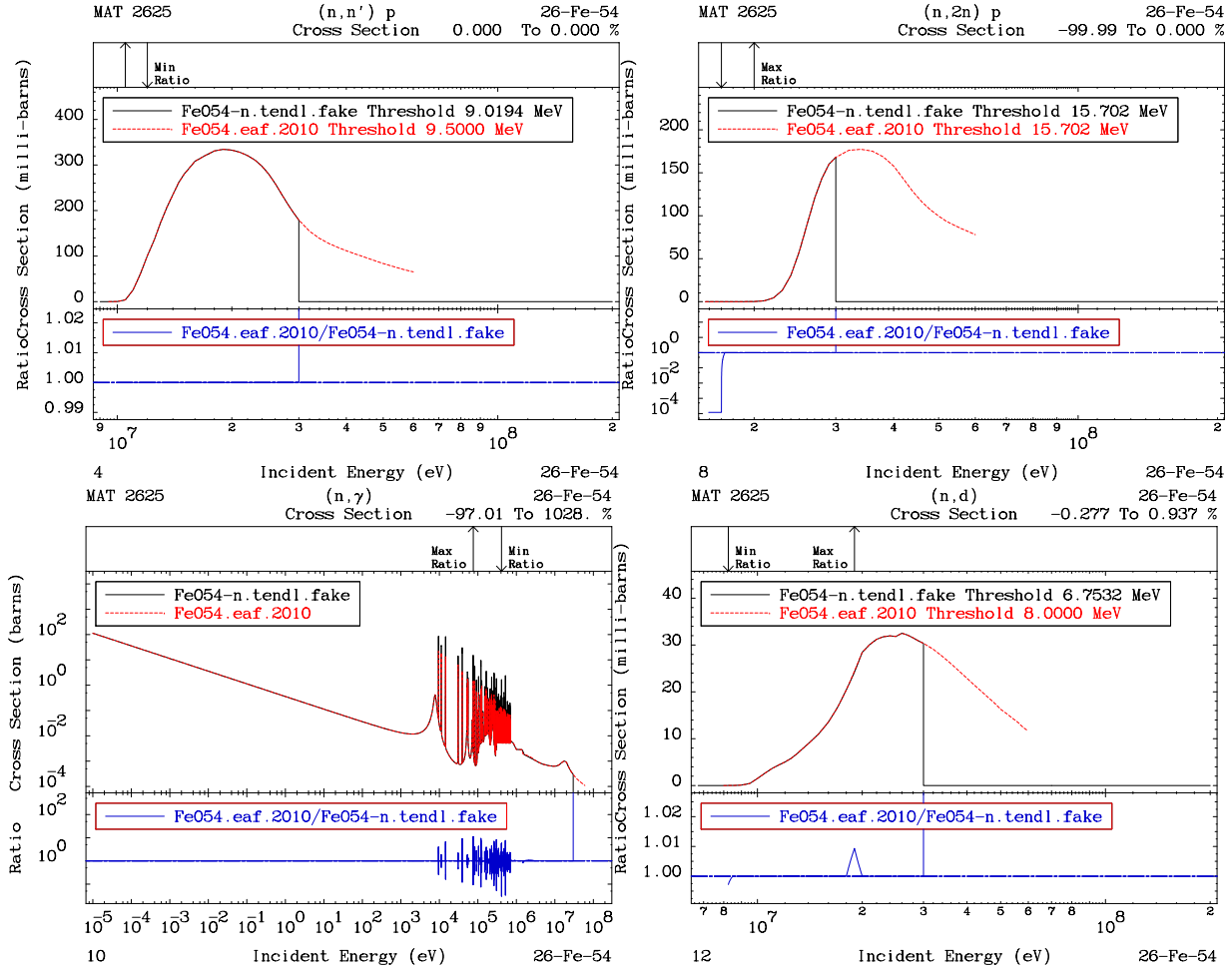
In practice, this functionality needs care to be properly implemented. In this work, it is extensively used to reproduce cross sections from the EAF-2010 library.

Even if this method can be applied to any cross sections, independently of the values of the original TALYS cross sections, it is better to *autonorm* cross sections which are already close to the imported ones. In order to minimize the modifications to other channels because of the sum rule, the cross section to be replaced should first be adjusted to values which are in agreement to the imported ones.

This can be achieved by adjusting the TALYS parameters so that the right cross section values are obtained. The prior agreement between the two sets of cross sections does not need to be perfect, but small differences (less than 5 %) assures that the modifications to other channels (such as elastic), or to related quantities (such as angular distributions, particle emissions) do not jeopardize physical consistency.

Autonorming: example on ^{54}Fe (not included in TENDL)

In order to demonstrate the capabilities of the TALYS system, an additional evaluation was prepared with *autonorms* to the major cross sections of ^{54}Fe from EAF-2010. The following channels were considered up to 20 MeV: (n,n'α), (n,n'p), (n,2np), (n,γ), (n,p), (n,d), (n,h).

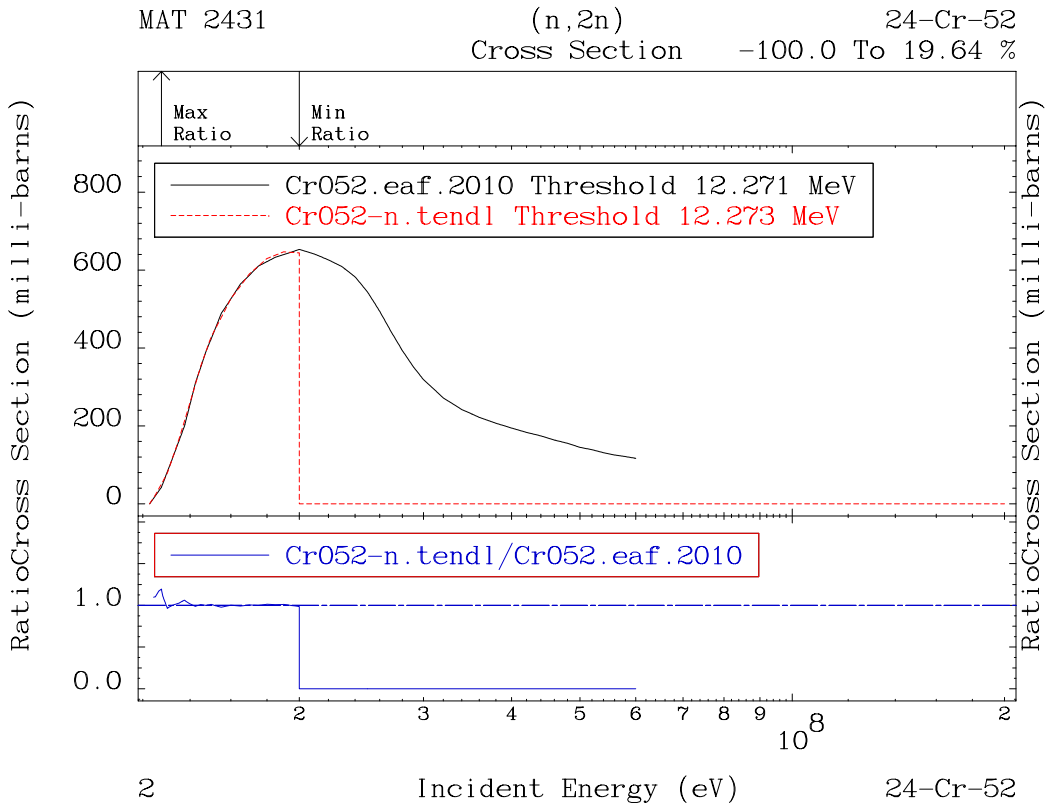


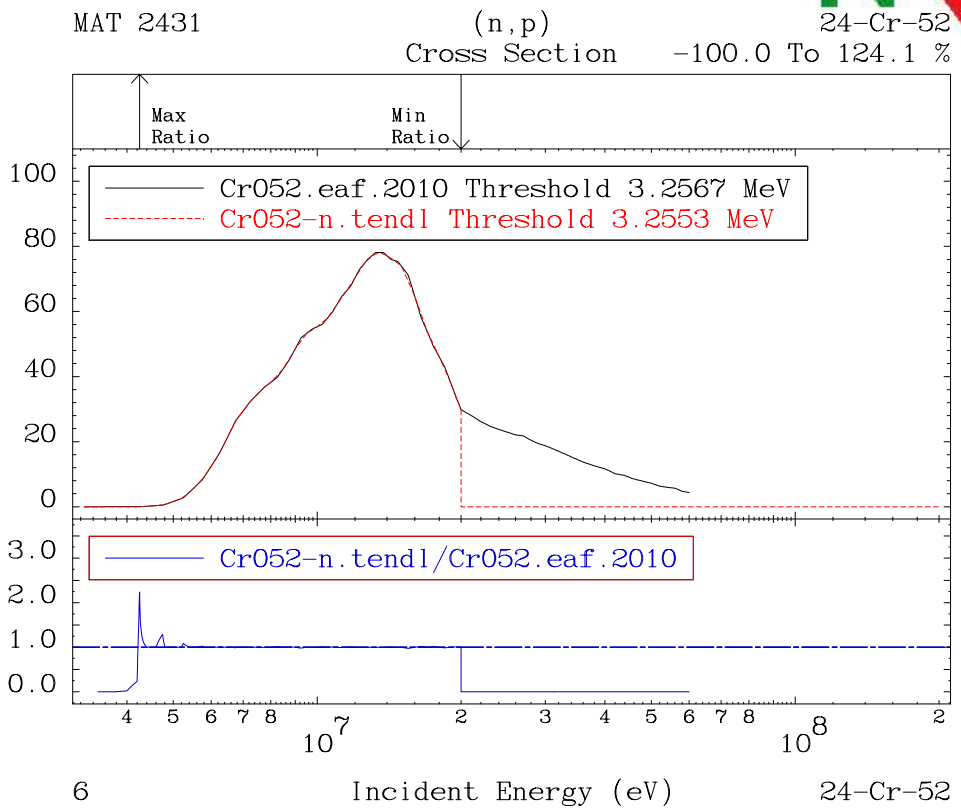
Importing other cross sections: *autonorming*

EAF-2010 differs from other libraries in the sense that not all major channels are explicitly given. The total and elastic cross sections are not provided.
In this work, some of the EAF-2010 cross sections are imported following the *autonorm* procedure. It was not the goal of TENDL-2011 to entirely reproduce EAF-2010, therefore not all EAF-2010 cross sections have been *autonormed*.
In total, 23 channels are *autonormed* in TENDL-2011 to the EAF-2010 library:

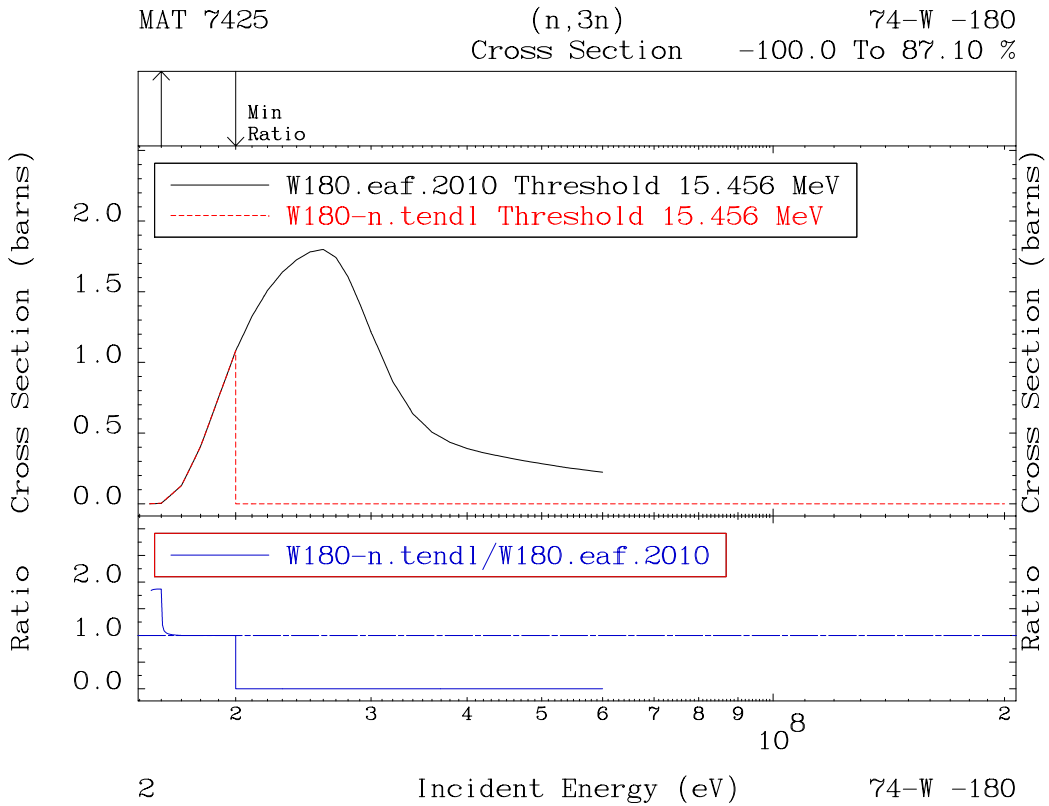
- ^{56}Fe(n,p)
- ^{52}Cr(n,2n), (n,p), (n,t)
- ^{180}W(n,3n)
- ^{182}W(n,2n)
- ^{183}W(n,p)
- ^{184}W(n,p) (n,n'p)
- ^{185}W(n,p) (n,n'p) (n,α), (n,2n)m_1
- ^{181}Ta(n,p)
- ^{51}V(n,n'α), (n,p), (n,t)
- ^{55}Mn(n,2n), (n,γ), (n,p), (n,t), (n,h), (n, α)

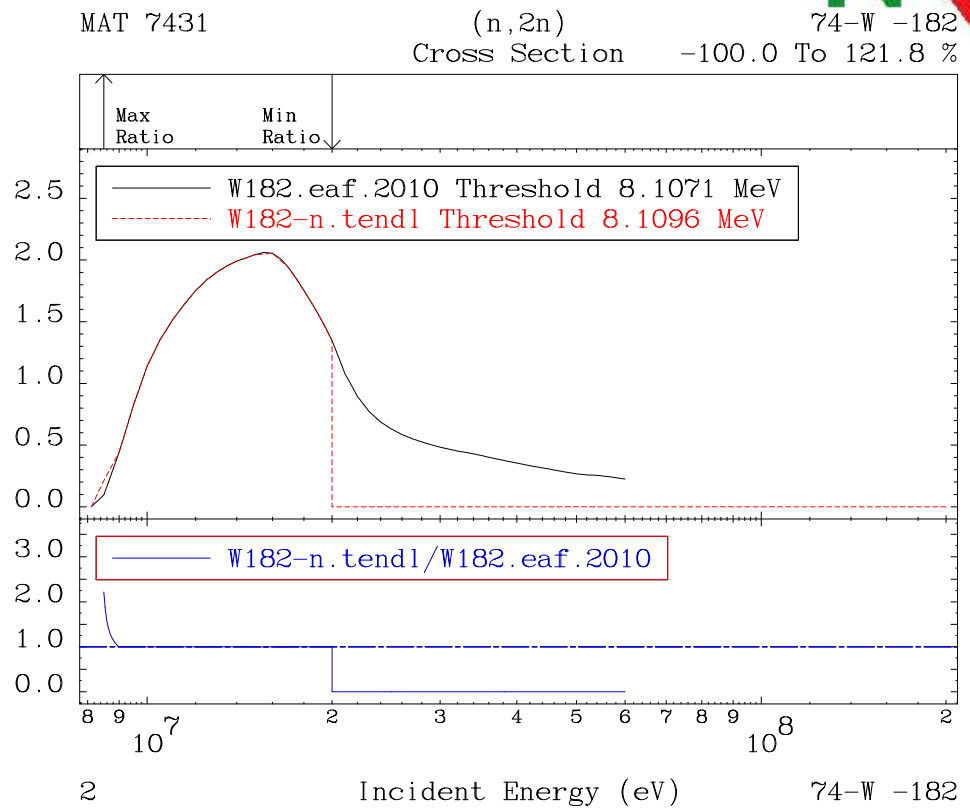
EAF/TENDL-2011 comparison: examples for ^{52}Cr



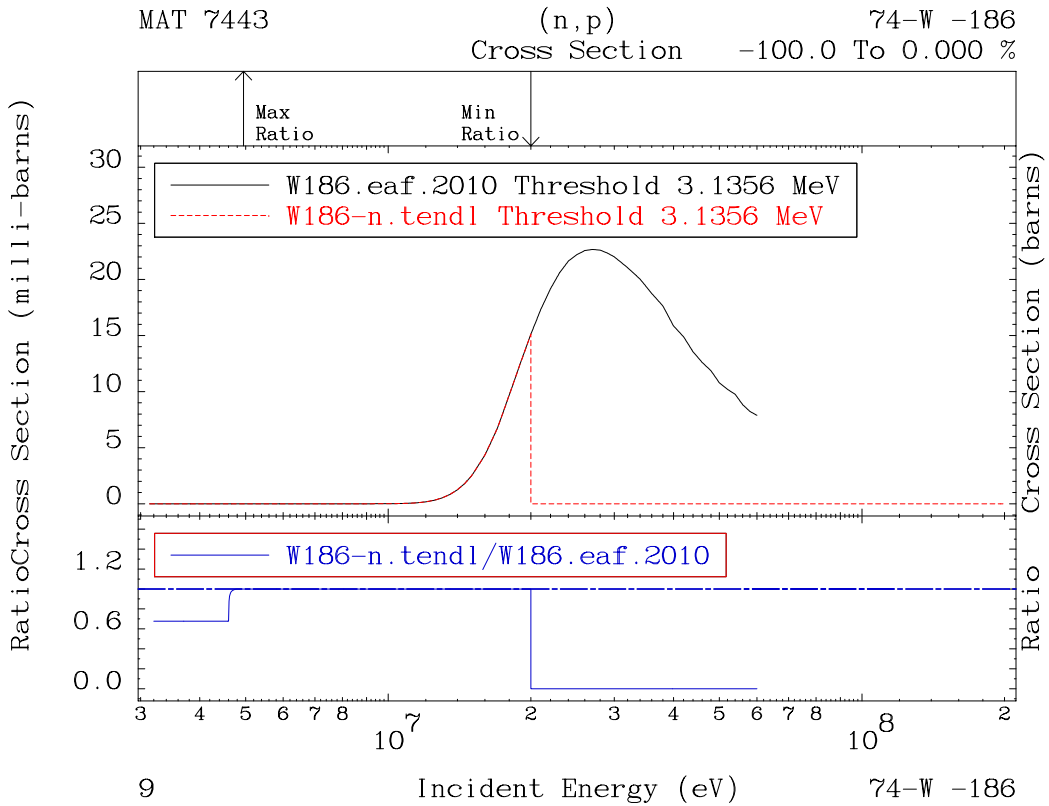


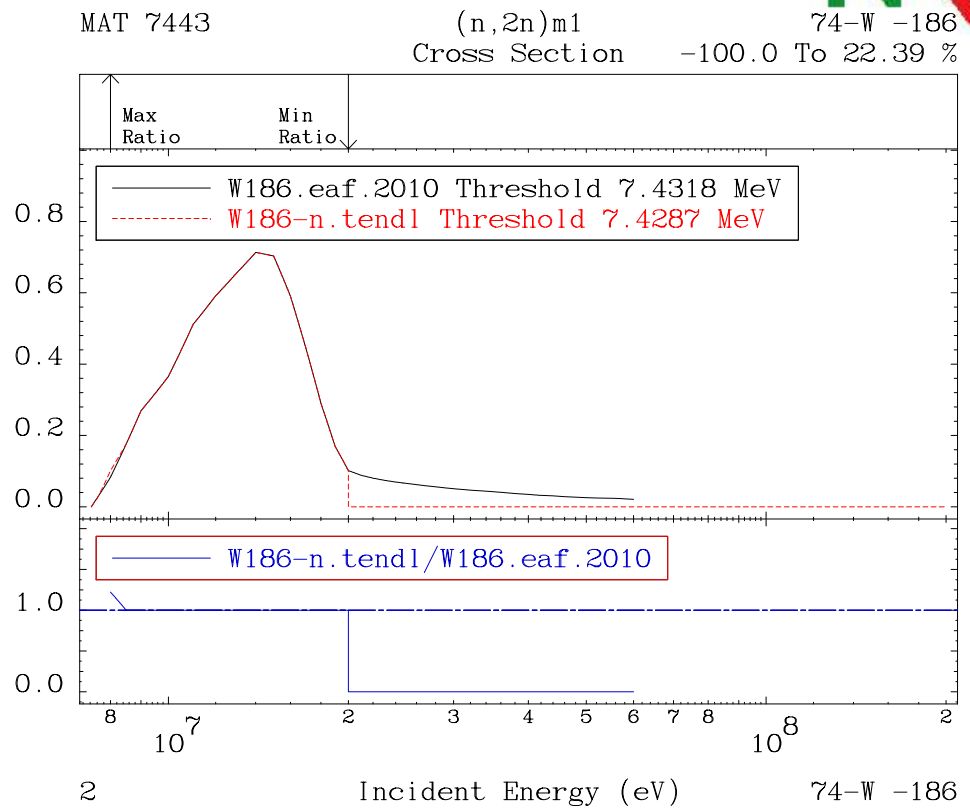
EAF/TENDL-2011 comparison: examples for ^{180,182}W



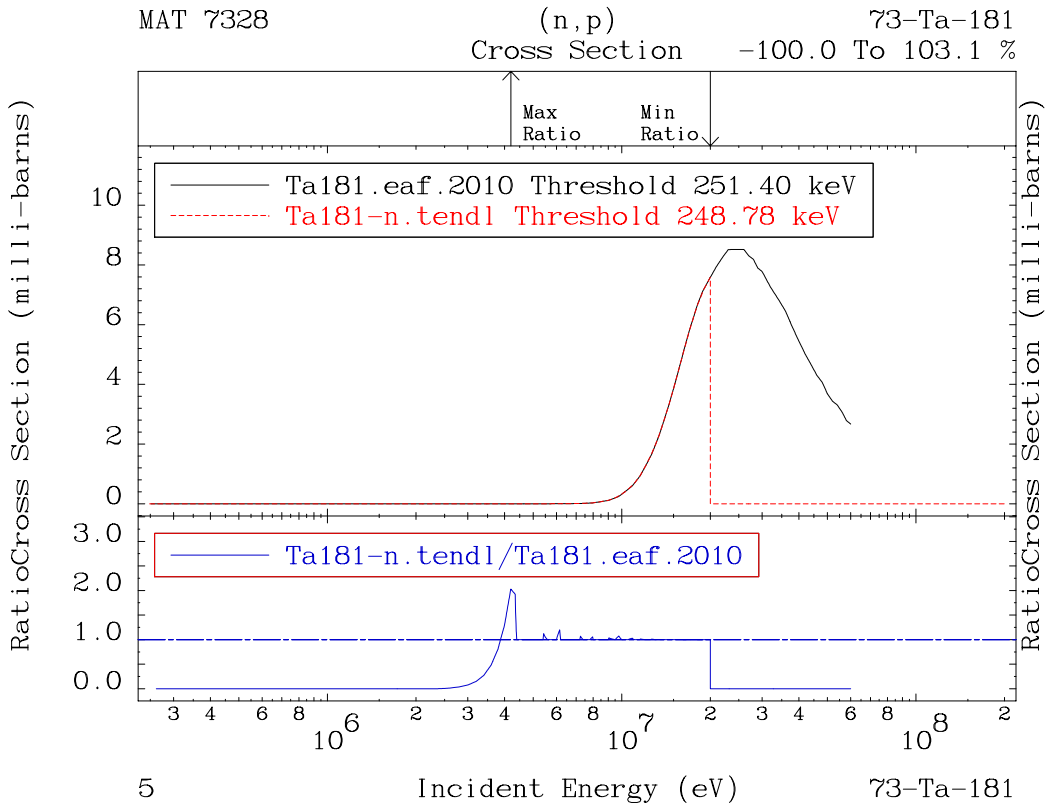


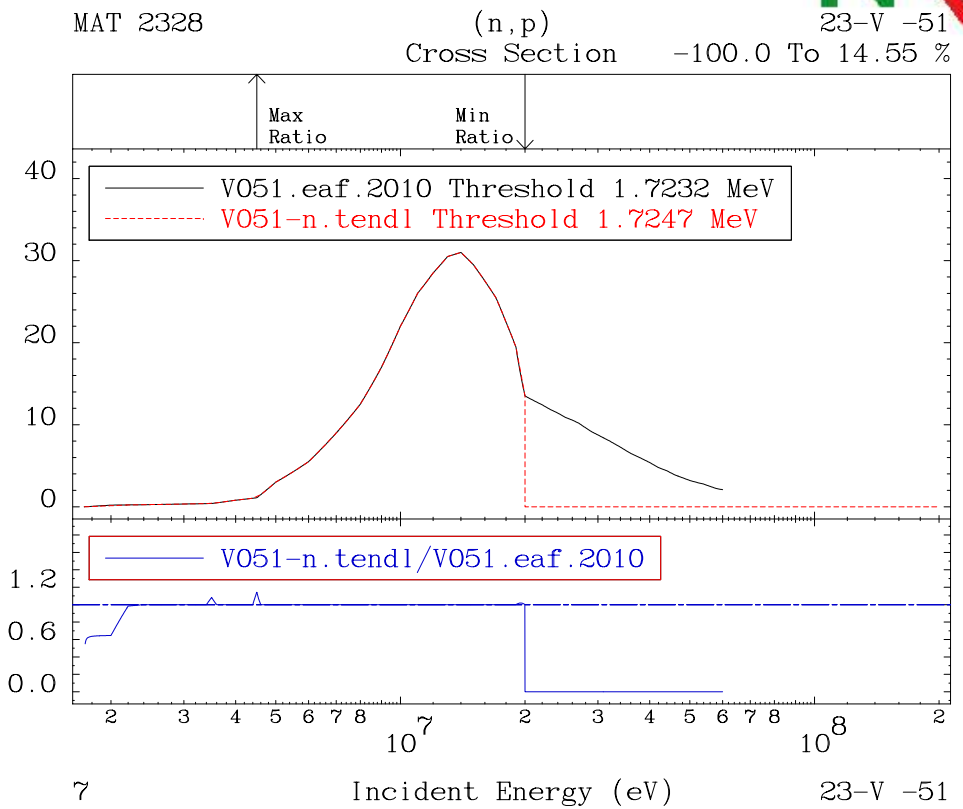
EAF/TENDL-2011 comparison: examples for ^{186}W



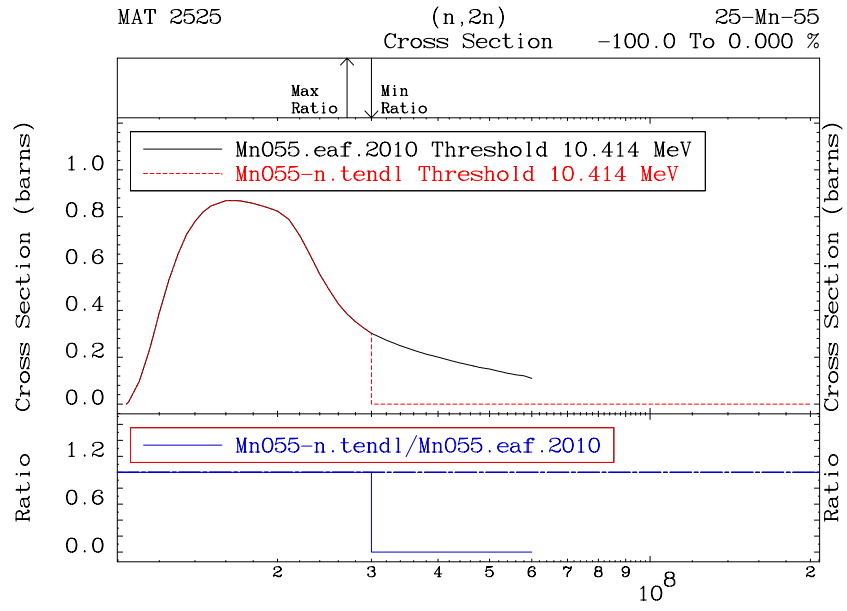


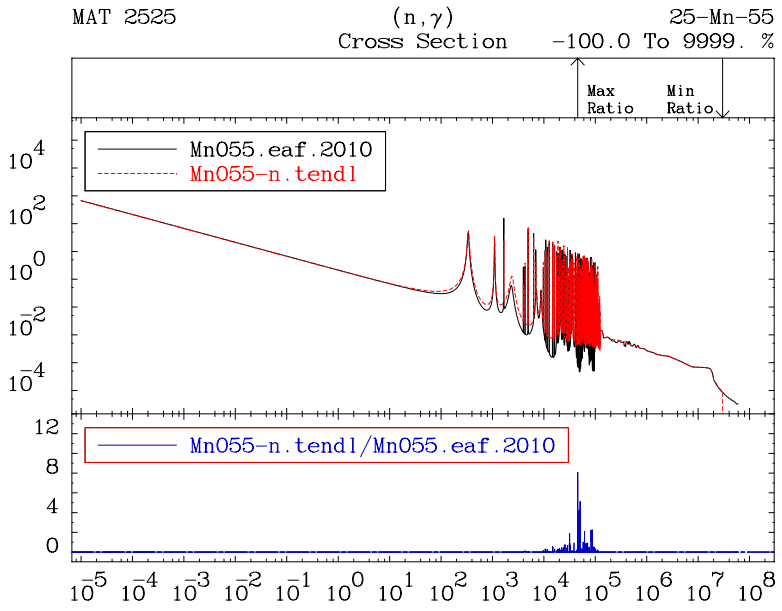
EAF/TENDL-2011 comparison: examples for ^{181}Ta, ^{51}V

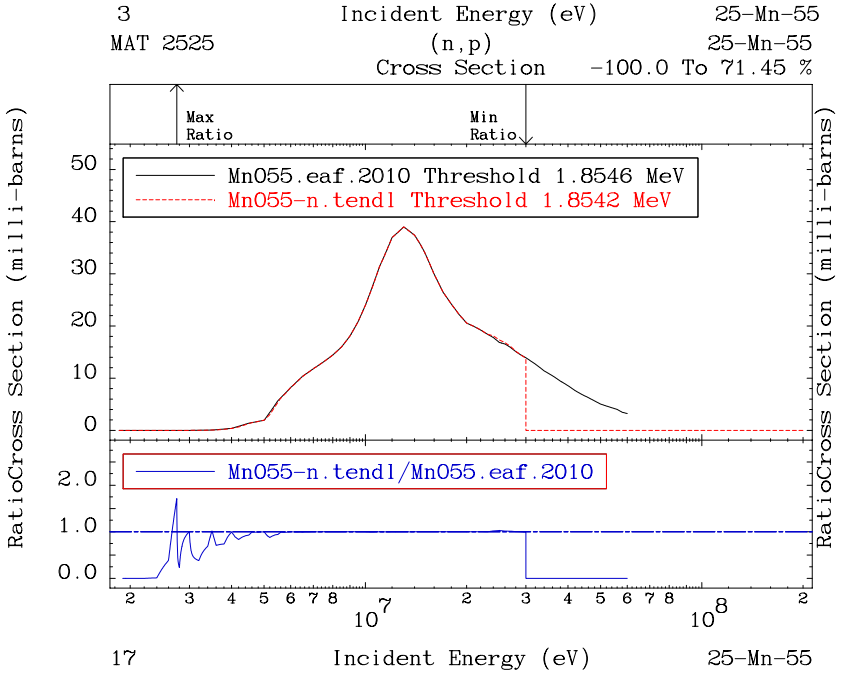


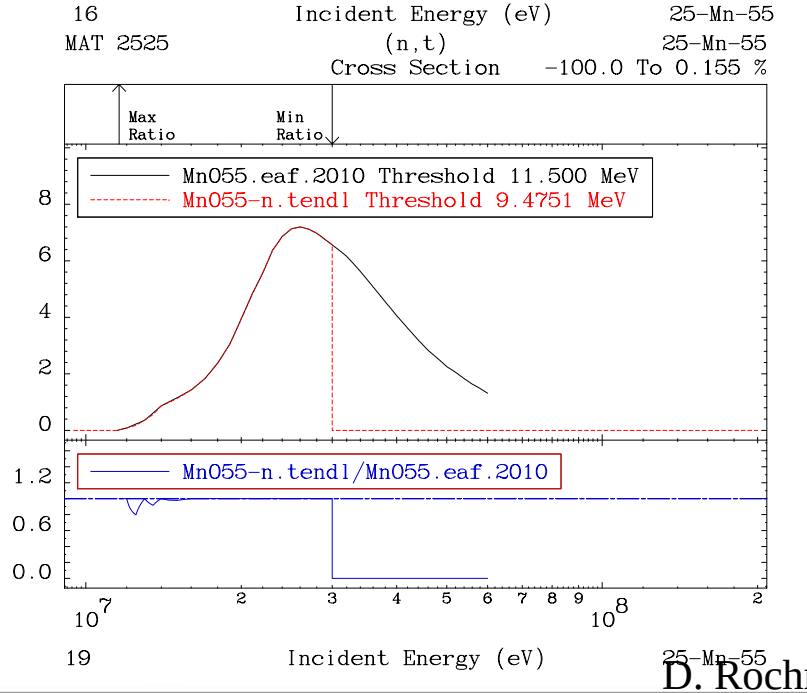


EAF/TENDL-2011 comparison: examples for ^{55}Mn



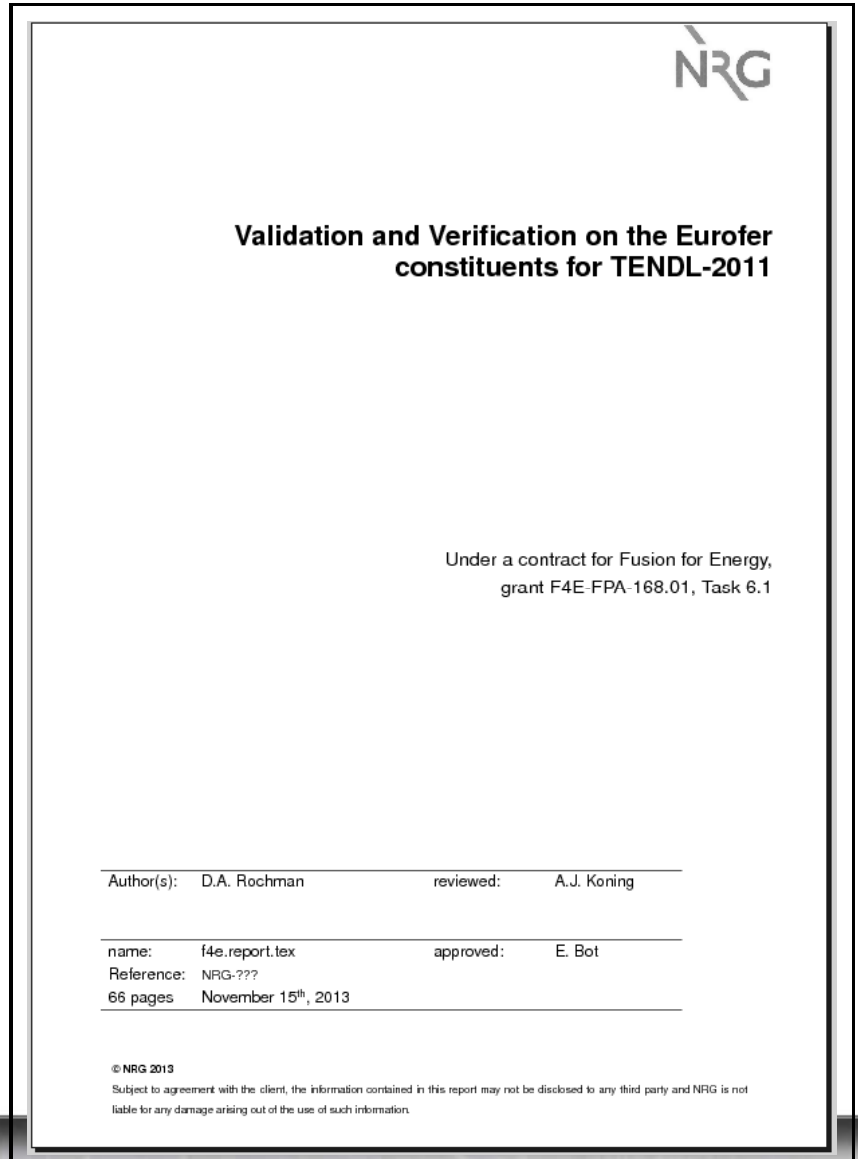






Reporting

A complete report on the comparison of TENDL-2011 and EAF-2010 libraries will be delivered by the end of 2013.



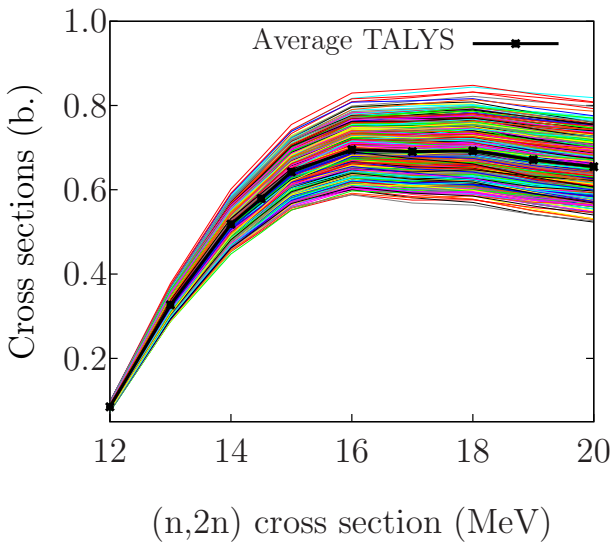
NRG

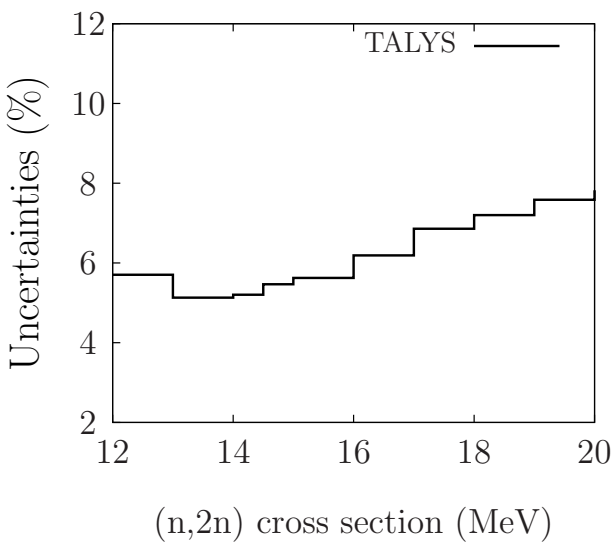
Validation and Verification on the Eurofer constituents for TENDL-2011

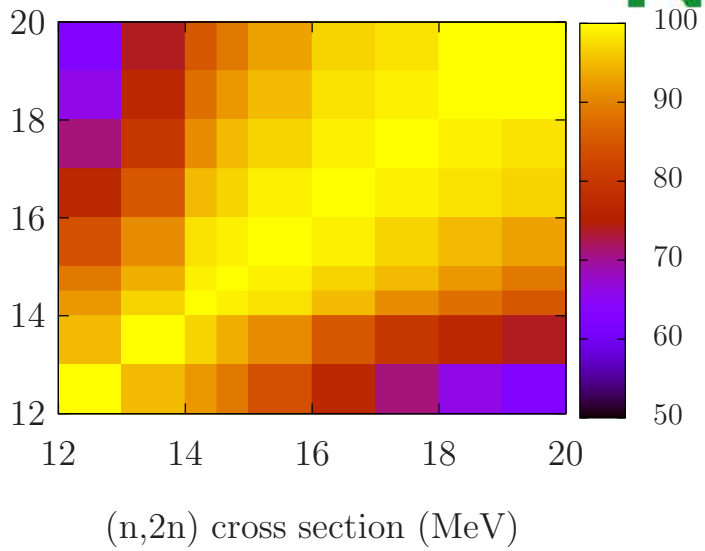
Under a contract for Fusion for Energy,
grant F4E-FPA-168.01, Task 6.1

Author(s):	D.A. Rochman	reviewed:	A.J. Koning
name:	f4e.report.tex	approved:	E. Bot
Reference:	NRG-???		
66 pages	November 15th, 2013		

Future work: update of covariances based on other libraries







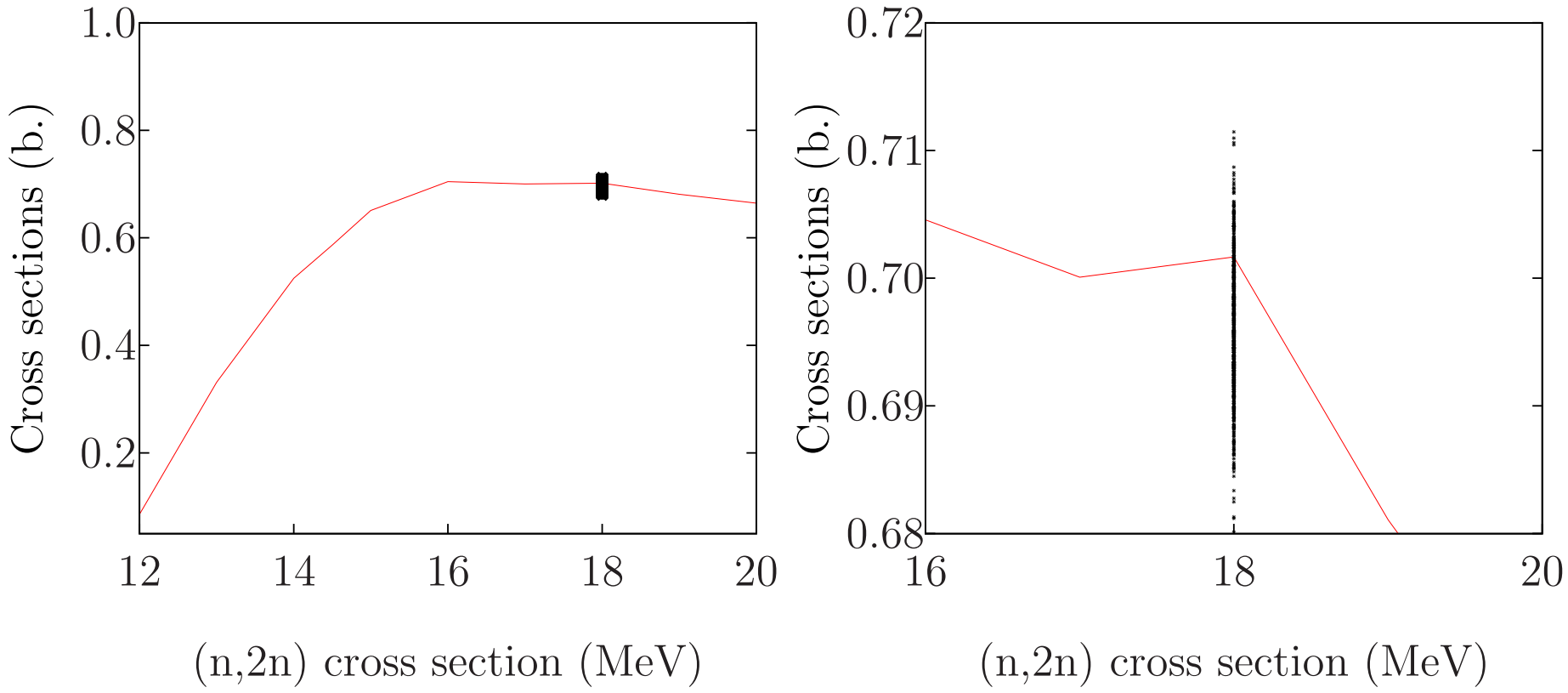
Exemple on ^{56}Fe(n,2n): from TALYS evaluations, the common comment is that the covariance matrix is too ”*stiff*”.

One solution is too include EXFOR data in a Monte Carlo process: if TALYS parameters can be random, EXFOR data can also be seen as probability distributions.

Update of covariances: 1 experimental point

E_n =18 MeV, xs_{EXFOR}(n,2n)= 700 mb $\pm$ 1 %

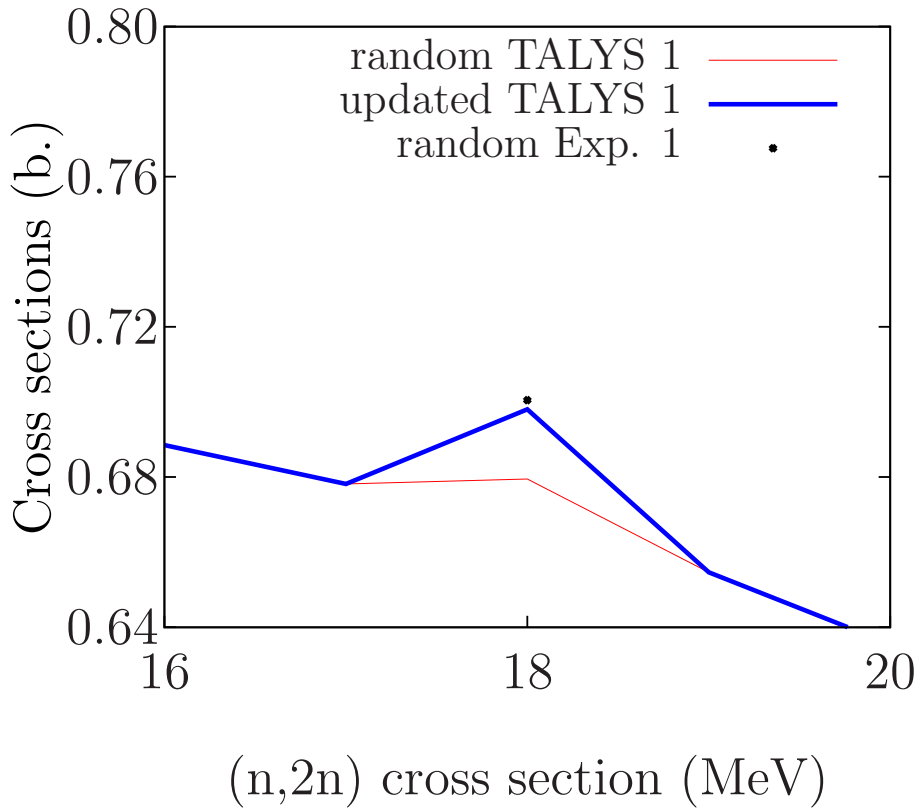
$\Longrightarrow$ xs_{EXFOR} can be seen as a Normal probability distribution with $\overline{xs}$ = 700 mb and $\sigma = 0.07$ mb

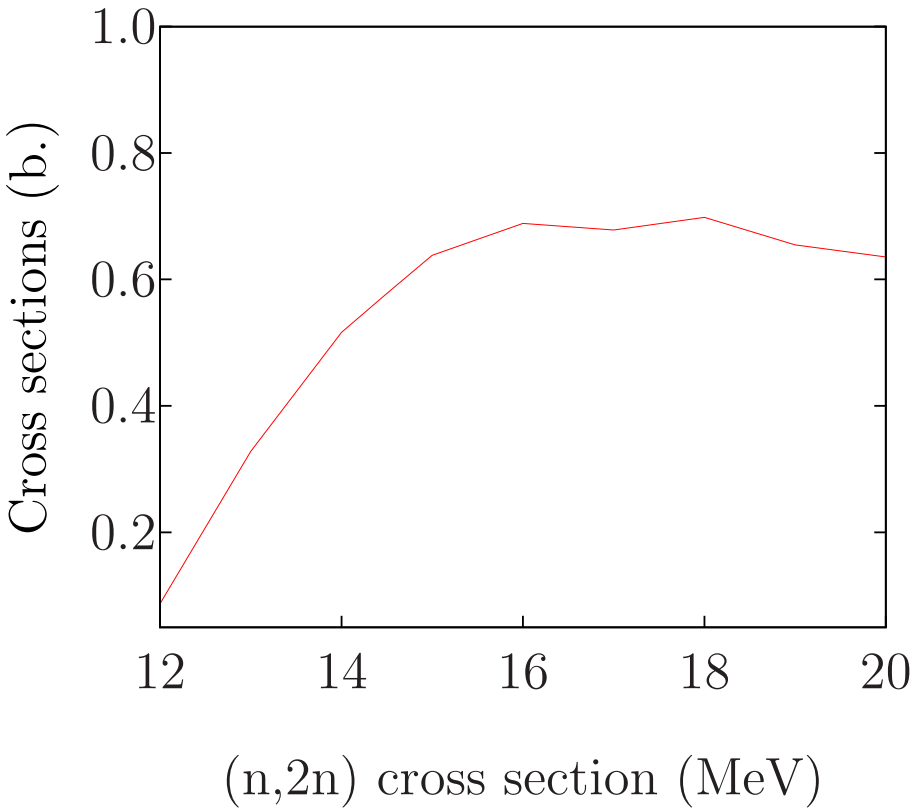


Update of covariances: 1 experimental point

$$\text{new xs}_1 = \omega_{Talys1} \times \text{xs}_{Talys1} + \omega_{Exp.1} \times \text{xs}_{Exp.1} \quad (1)$$

ω_{Talys1} and $\omega_{Exp.1}$ are weights, and xs_{Talys1} and $\text{xs}_{Exp.1}$ random cross sections:





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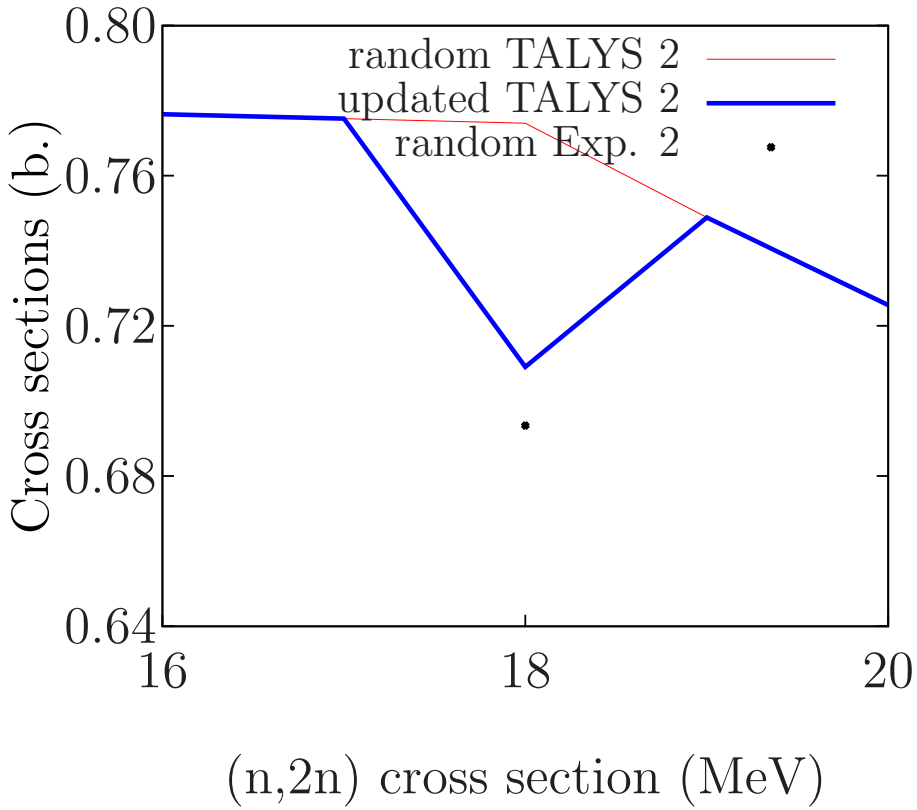

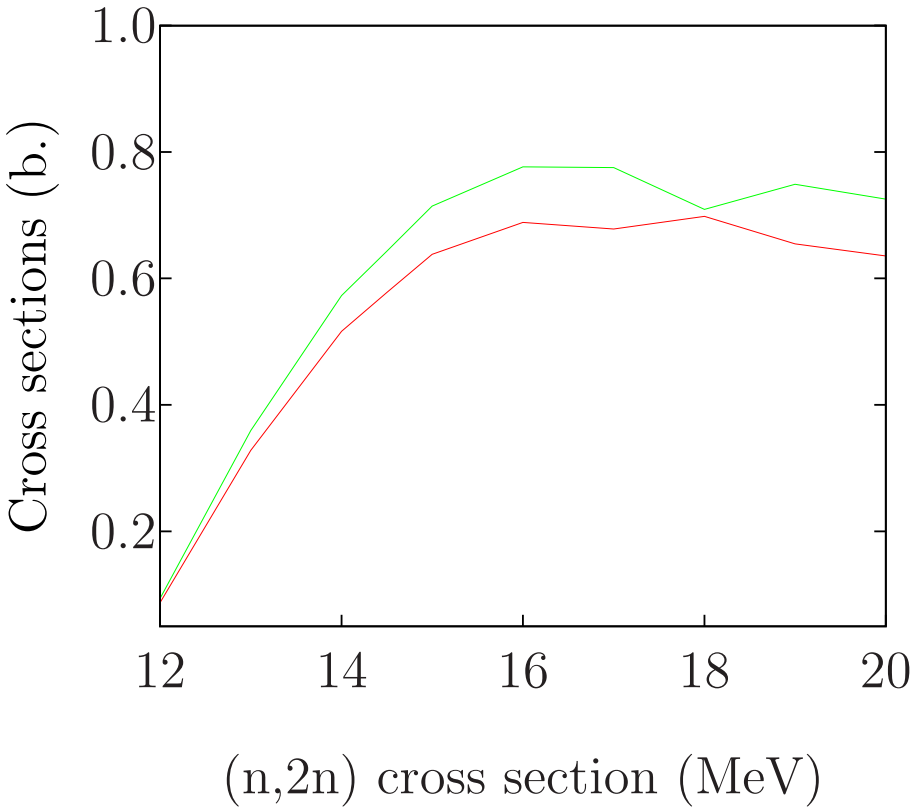

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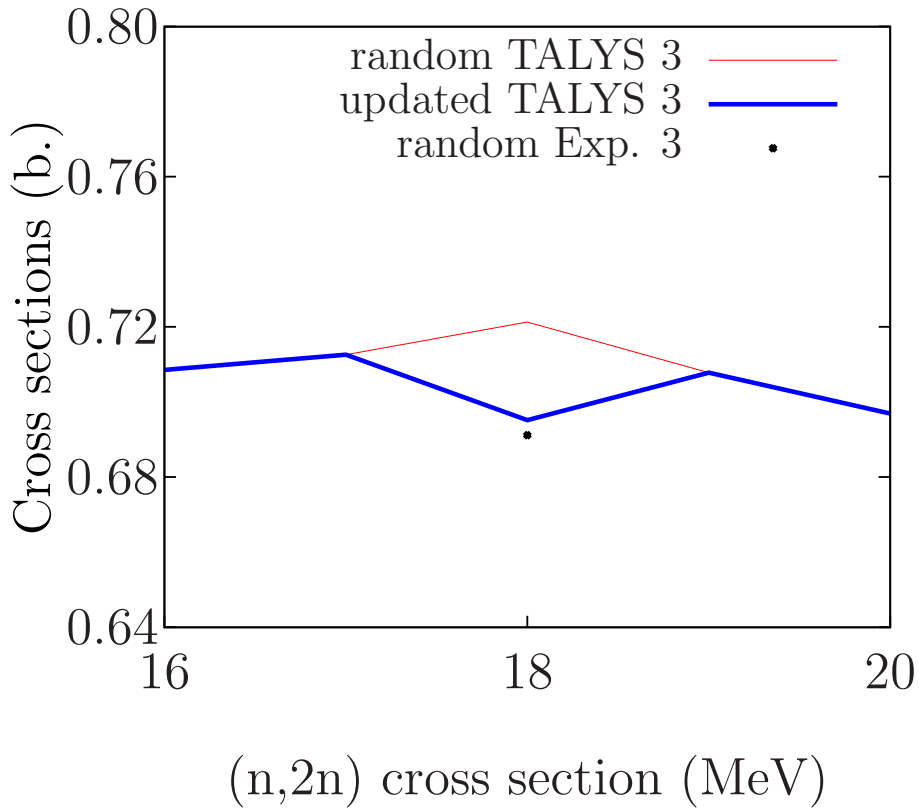

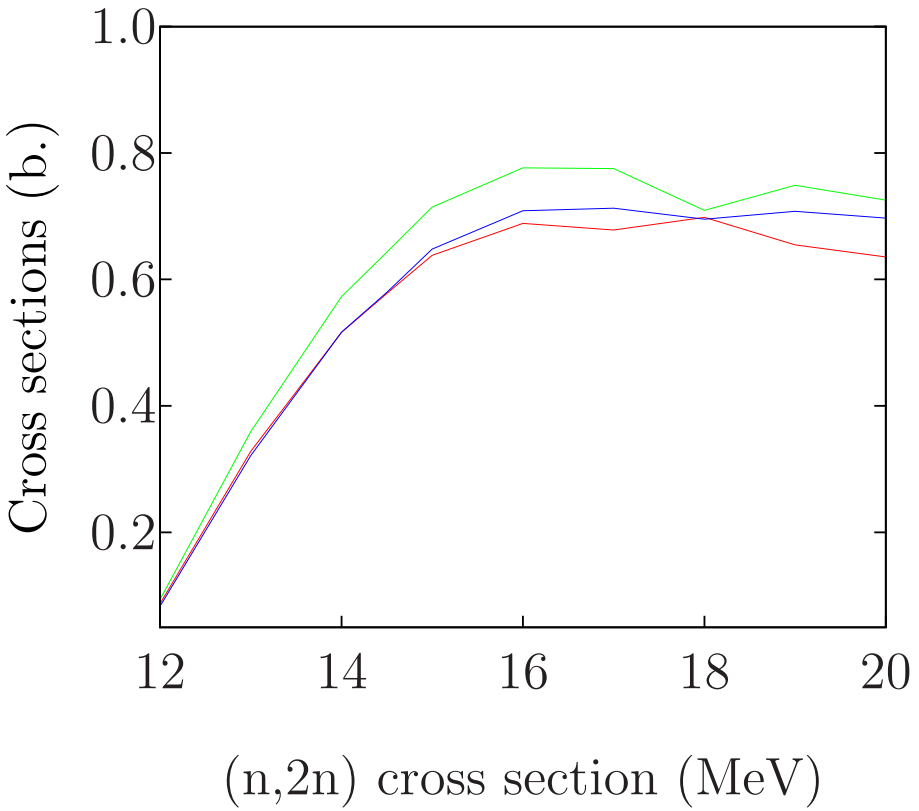

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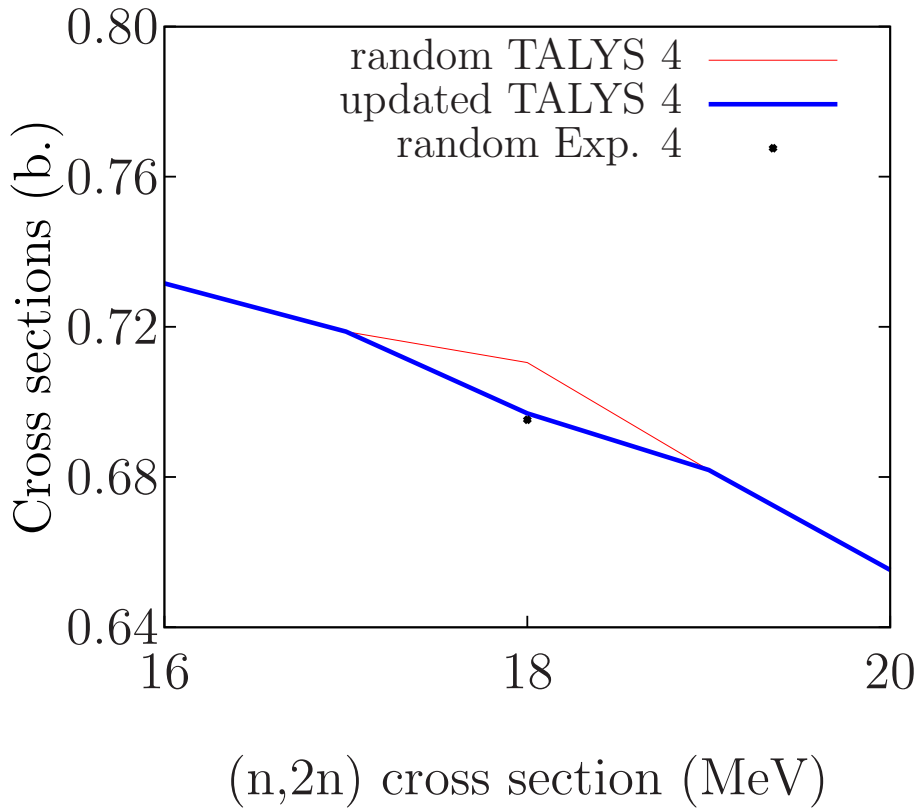

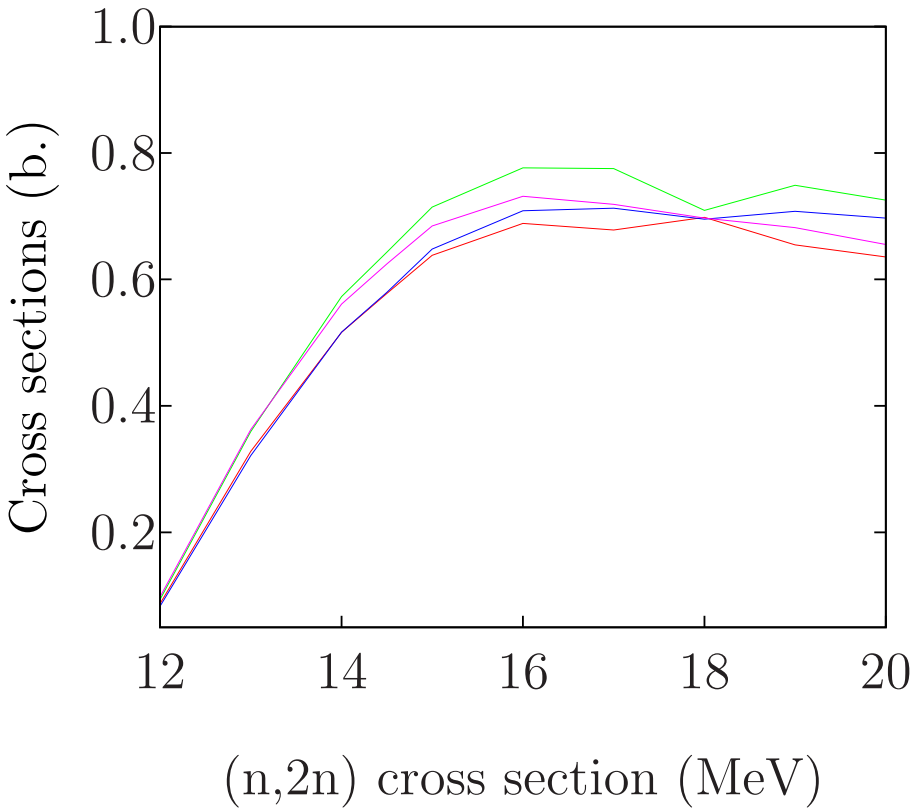

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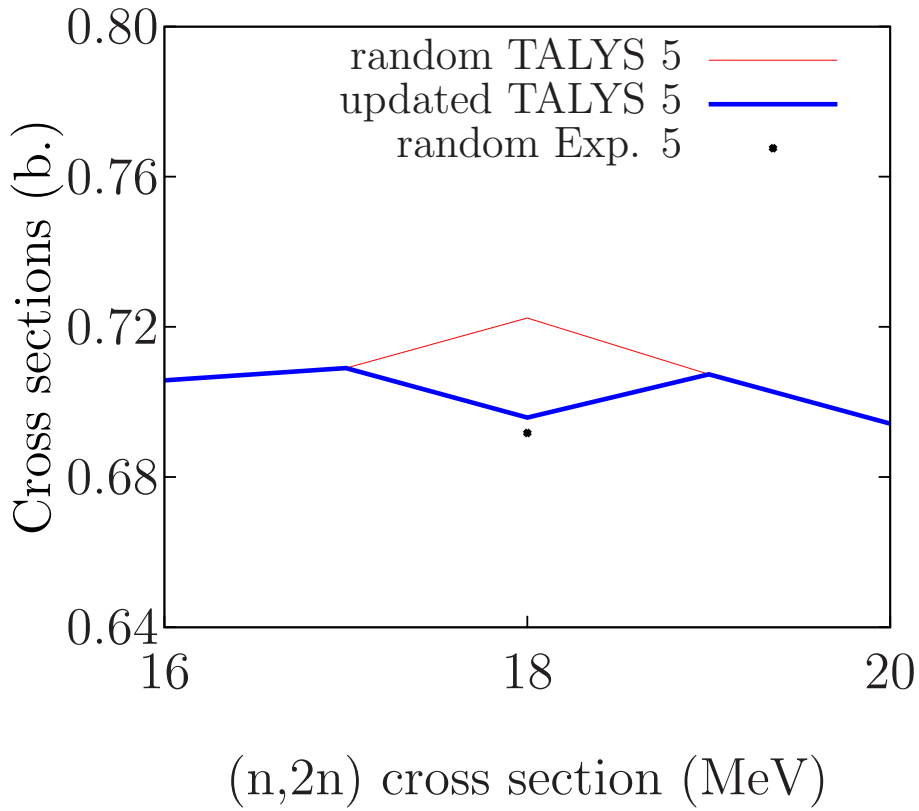

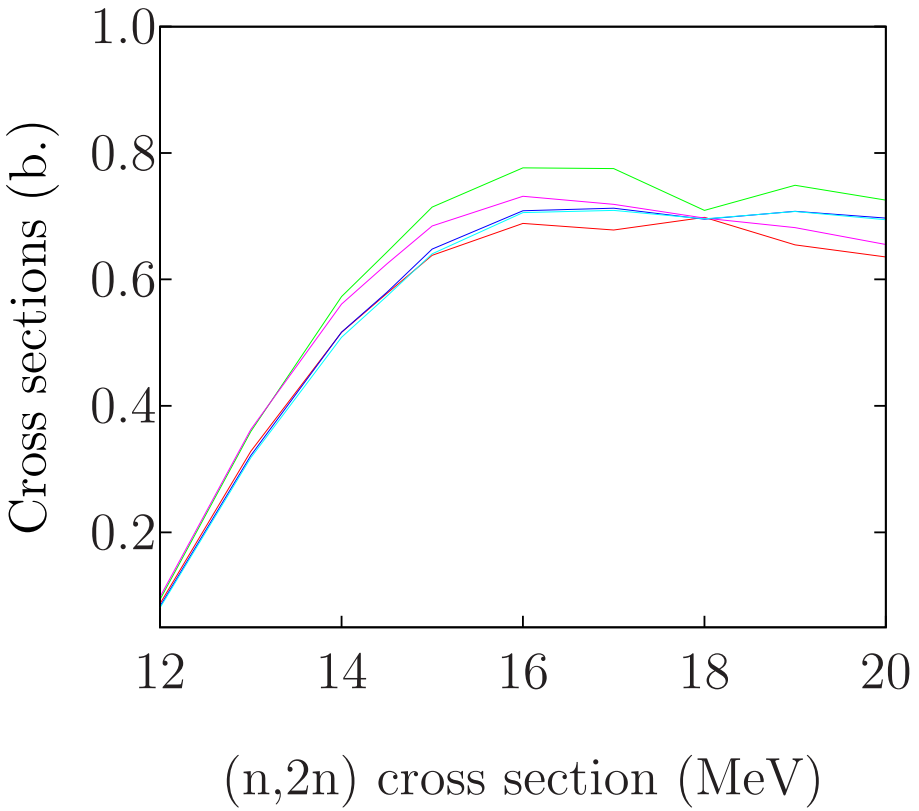

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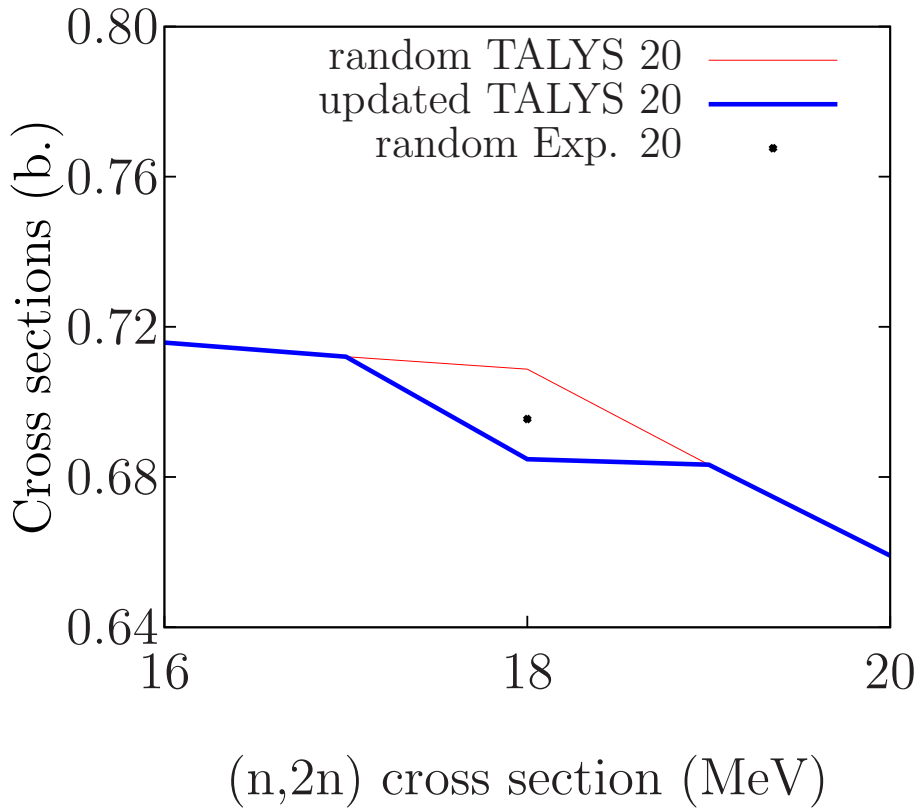

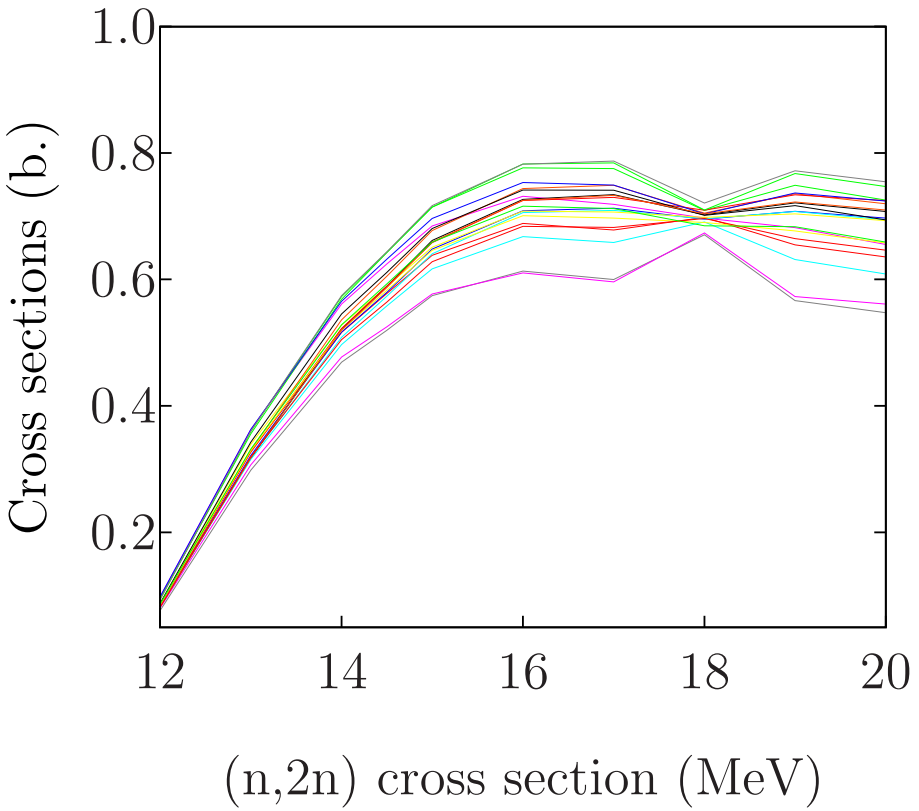

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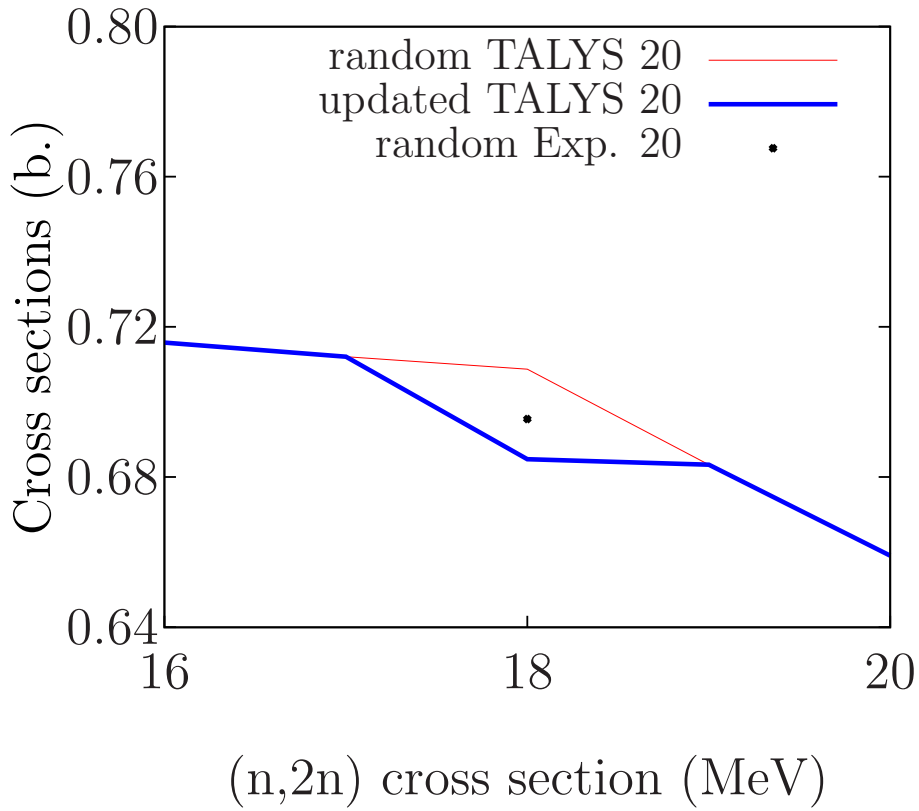

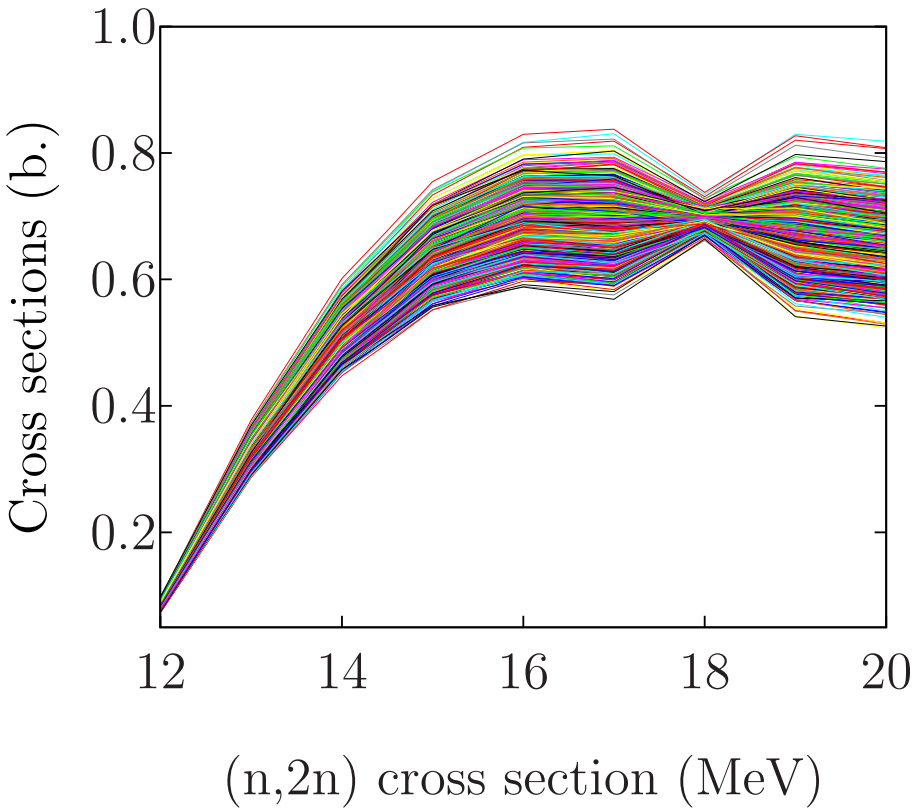

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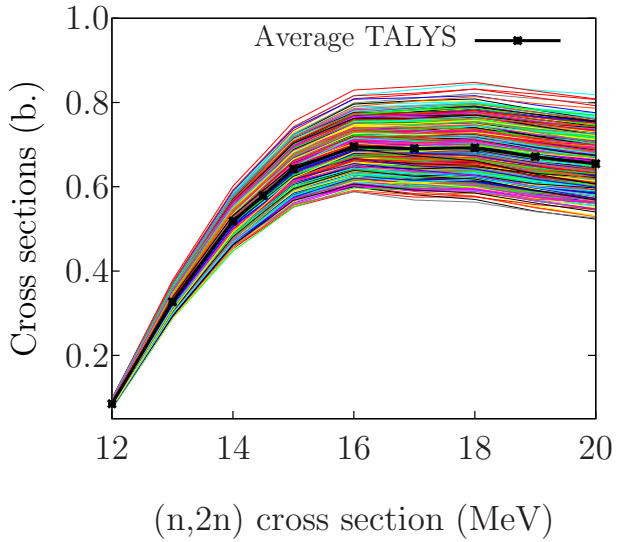
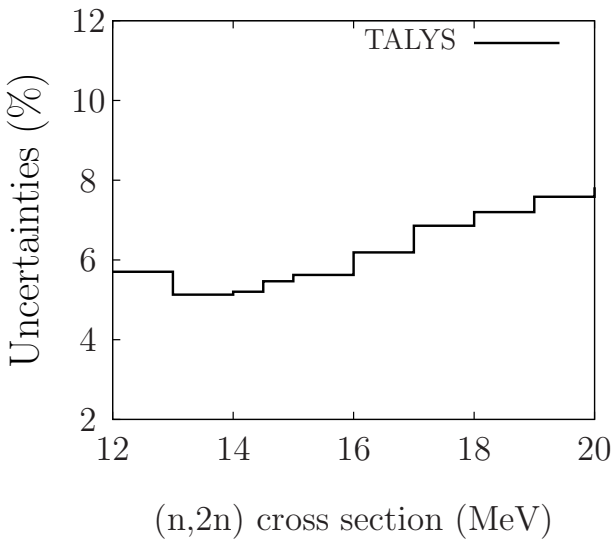
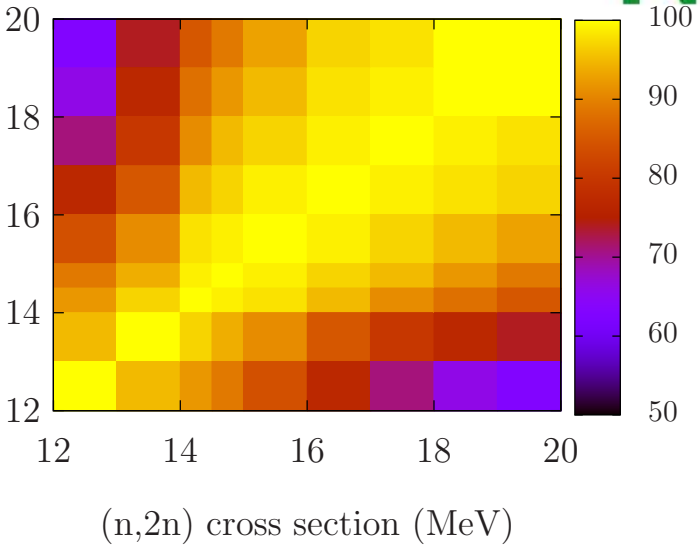
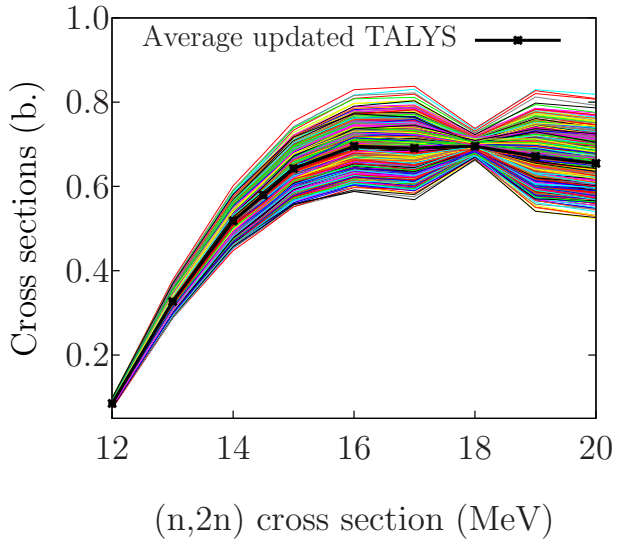
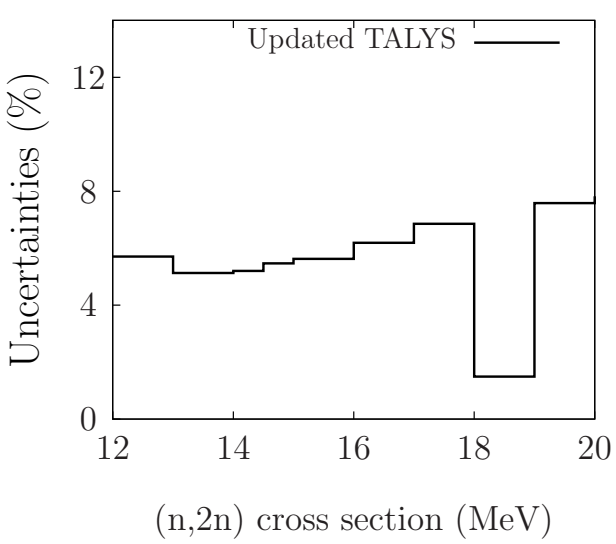
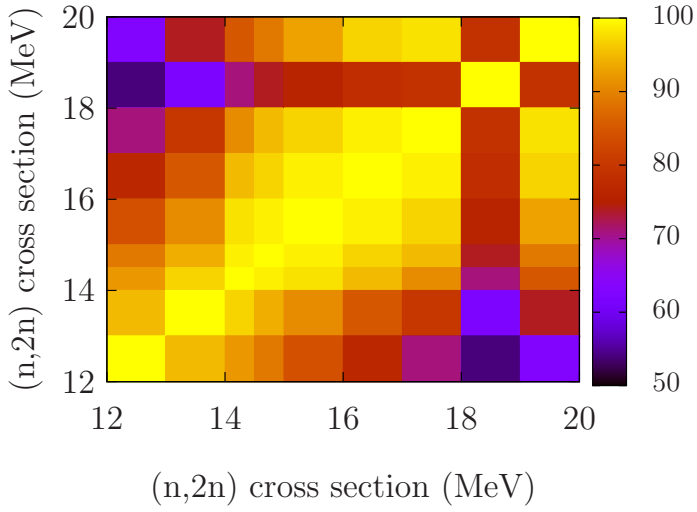




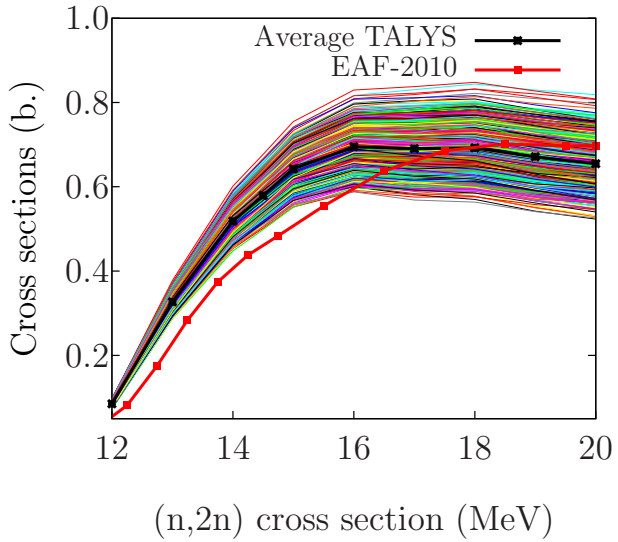


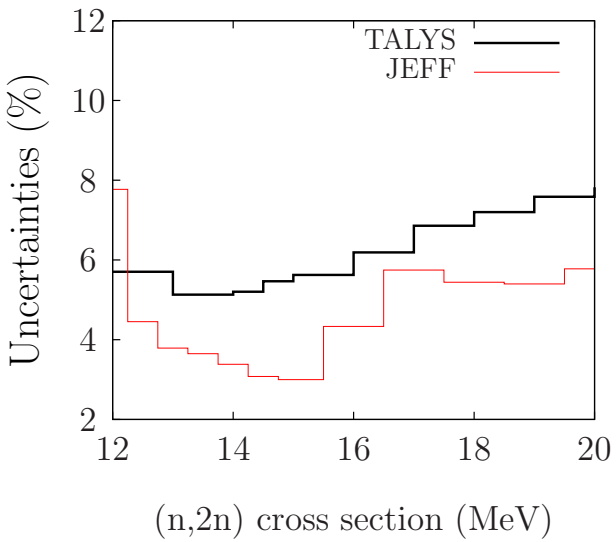


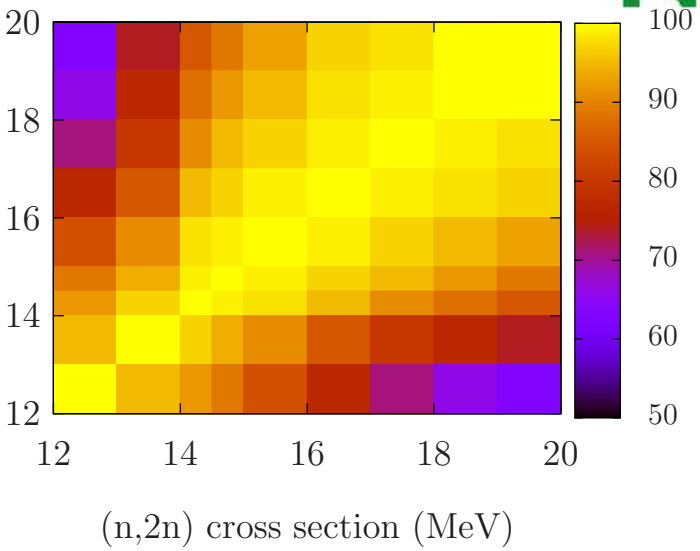


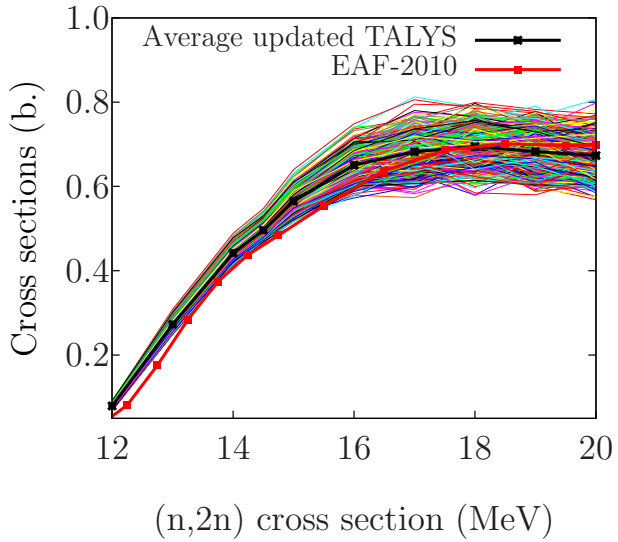


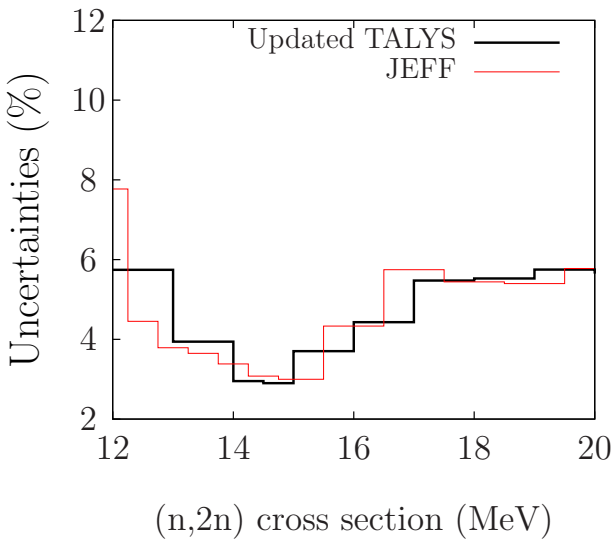
Update of covariances: same but with EAF-2010

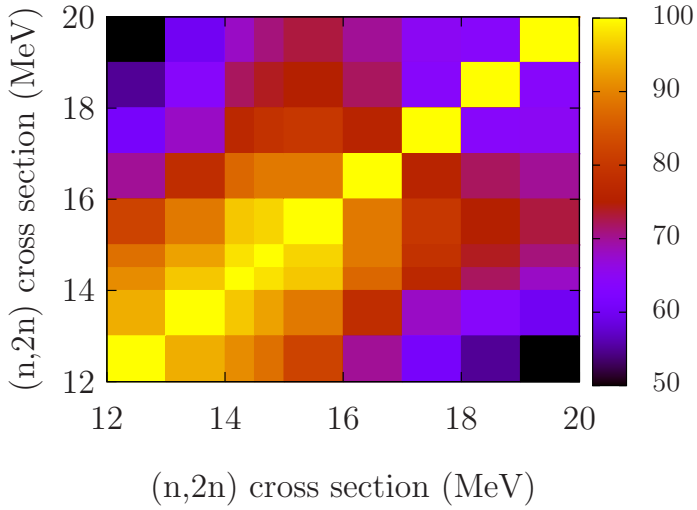












Conclusions and Future improvements

- Cross sections for 16 isotopes (Eurofer constituents) were compared between TENDL-2011 and EAF-2010 (^{54,56,57,58}Fe, ^{50,52,53,54}Cr, ^{180,182,183,184,186}W, ^{181}Ta, ^{51}V and ^{55}Mn),
- Two types of results can be observed:
  - in the case of "*autonormed*" (automated import) cross sections, the comparison between TENDL-2011 and EAF-2010 shows a very good agreement,
  - in the case of original TALYS calculations, the comparison between TENDL-2011 and EAF-2010 shows expected differences.
- Future work: TENDL for fusion, covariances for fusion and/or validations

☺And finally nuclear data world domination (and world peace).