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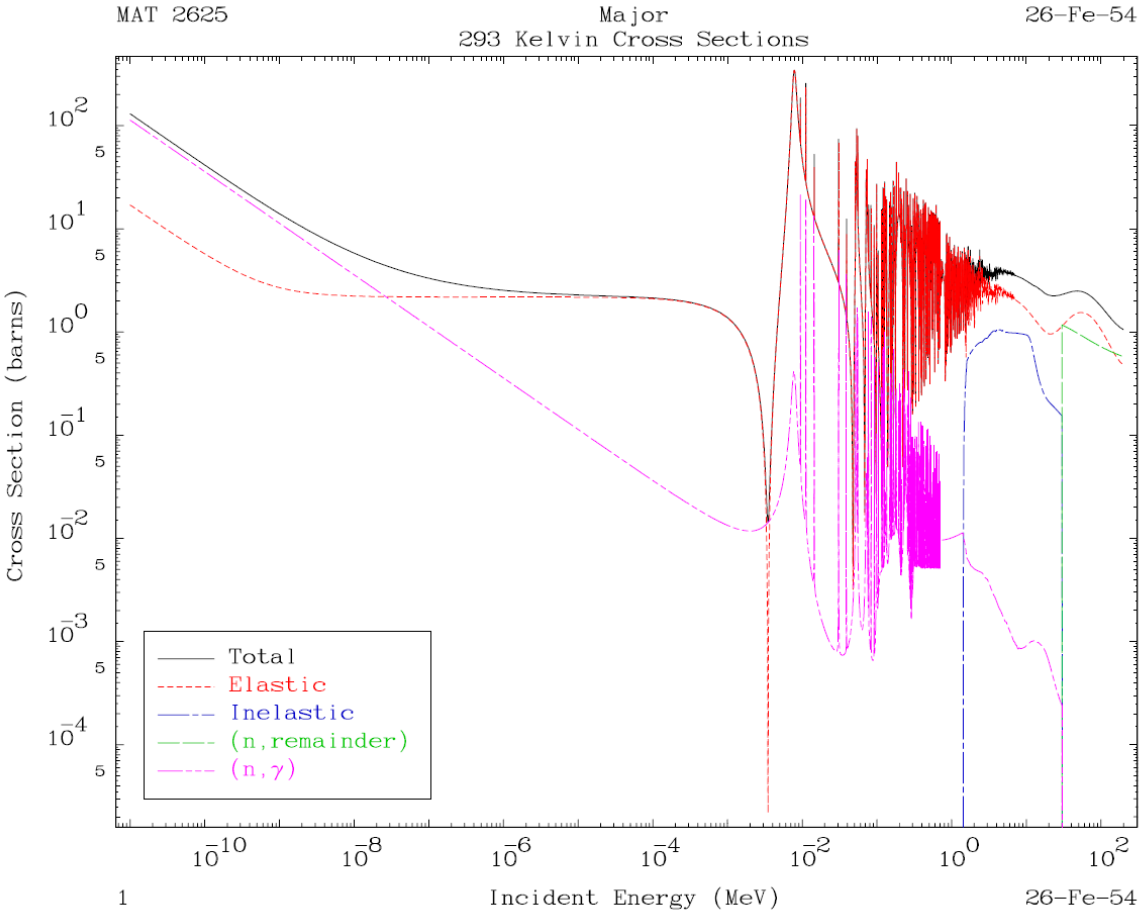
How well do we know some cross sections ?

EURADOS WP 6-9-11, Karlsruhe, Germany, March 1, 2017

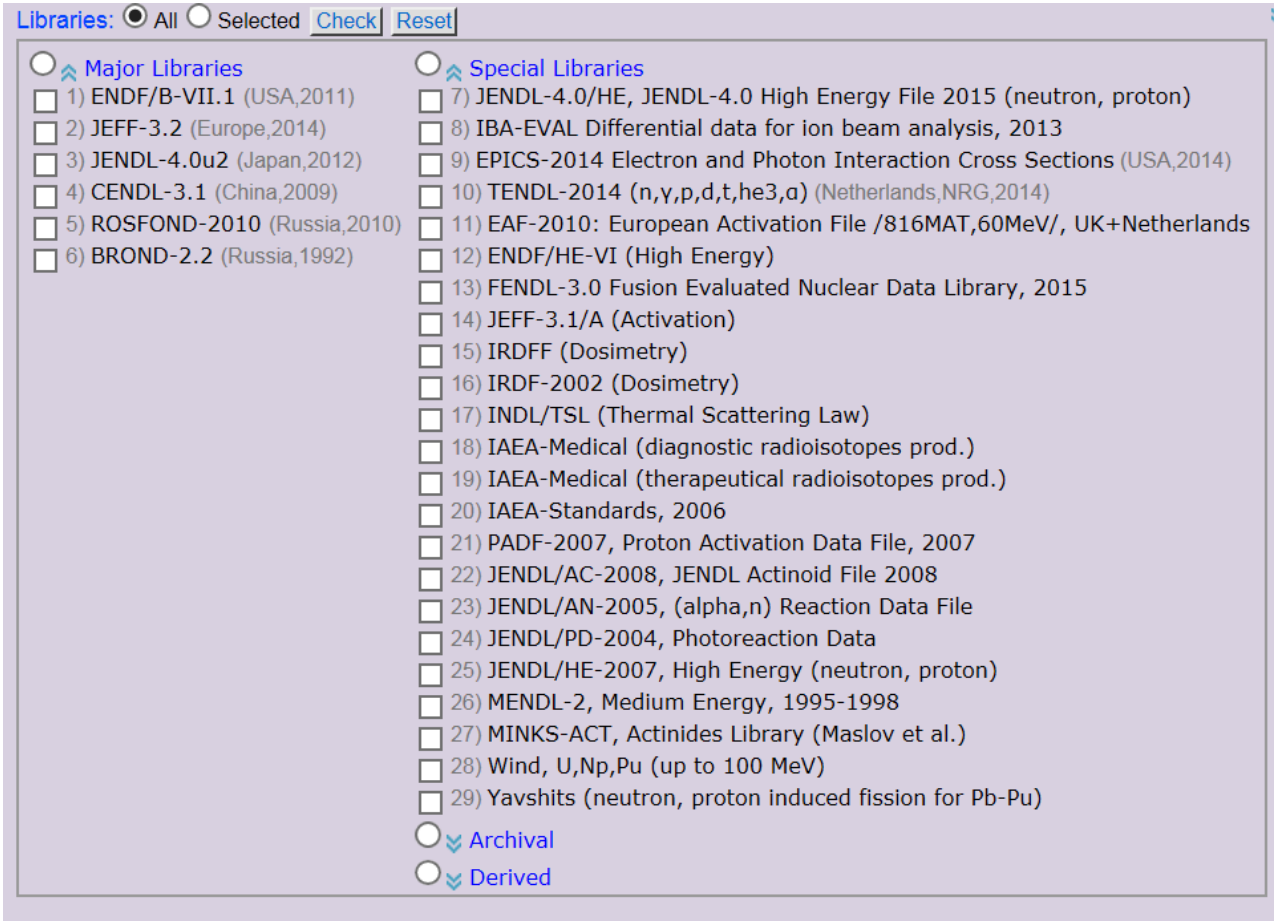
Summary

- Do we know neutron cross sections?
- Experimental evidence of discrepancies
- Modeling uncertainties
- Conclusion



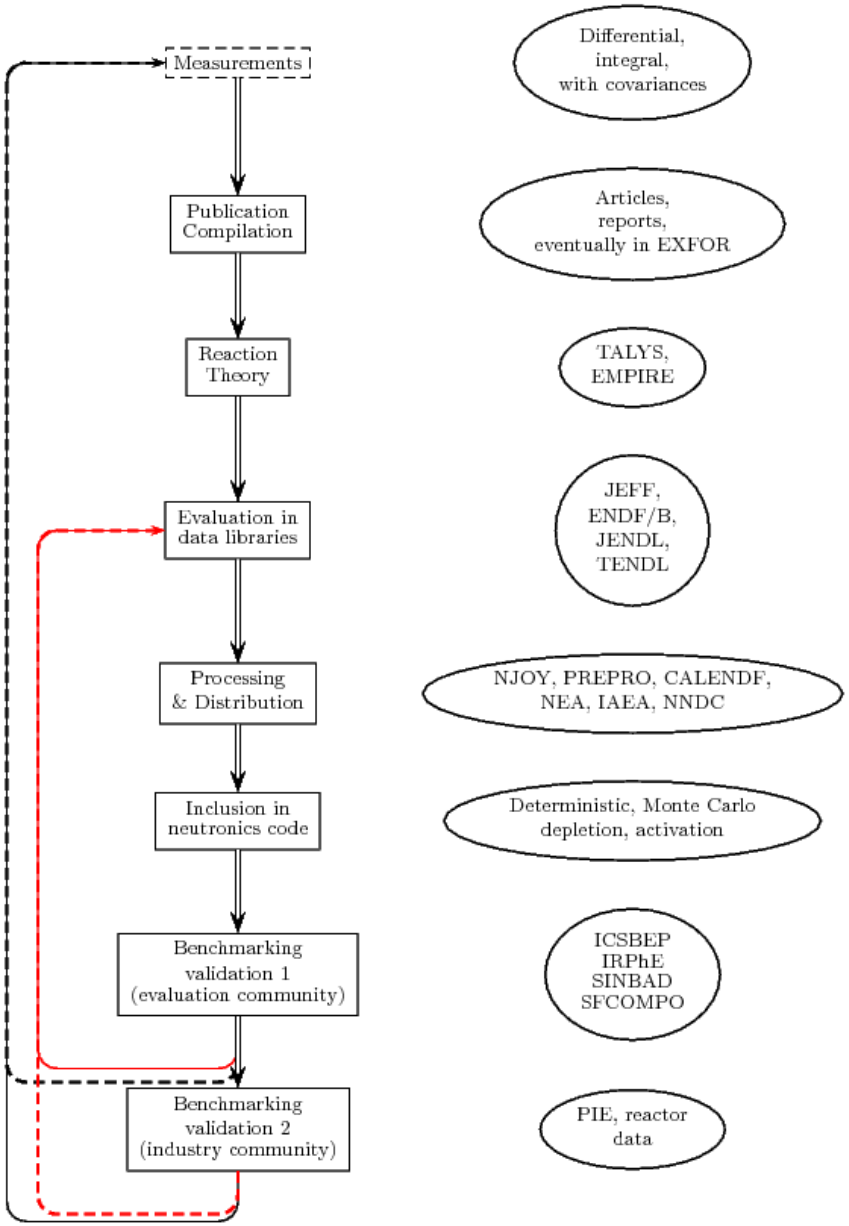
Neutron cross sections: state of knowledge

- In the following, neutron-induced reaction up to 20 or 200 MeV
- Most of the efforts were for thermal/resonance/fast range (in this order)
- Many nuclear data libraries (US, NEA, Japan, …)
- Many dedicated libraries (fusion, dosimetry, reactor…)



https://www-nds.iaea.org/exfor/endf.htm

Nuclear data life cycle



How do know that we don't know

- Cross section library = measurements + modeling

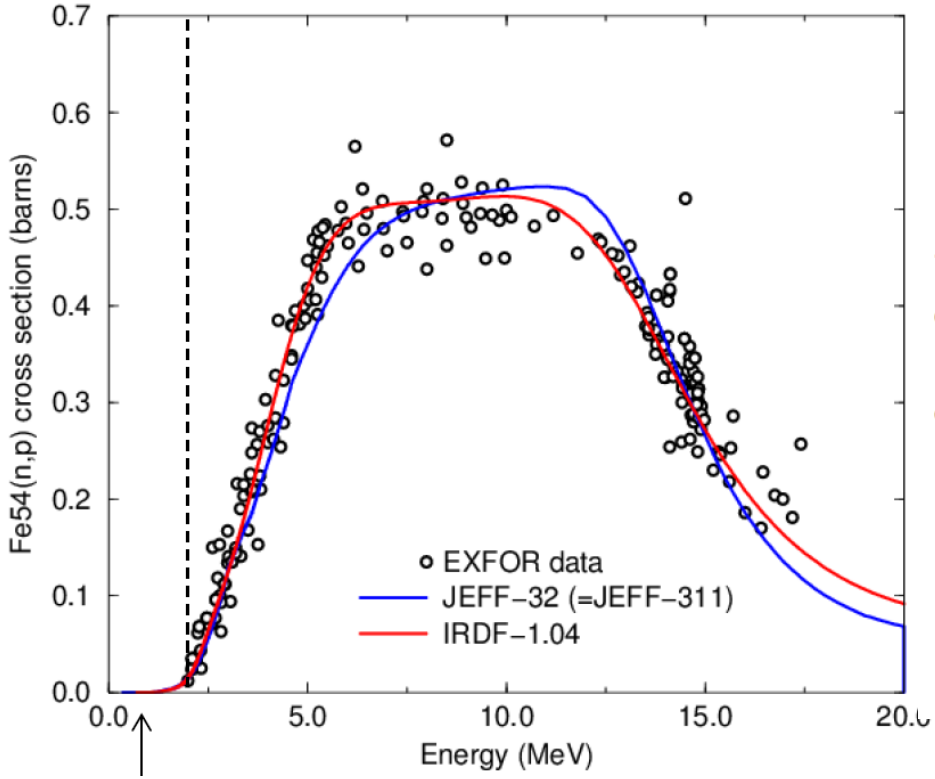
- In many libraries, cross sections for the same reactions are different, why ?
  - Not enough experimental data ?
  - Discrepant experimental data ?
  - Wrong modeling ?
  - Discrepant experiment/model ?
  - Different interpretation (human, processing, simulation)?

- Why many libraries ?
  - Different application field
  - Different knowledge

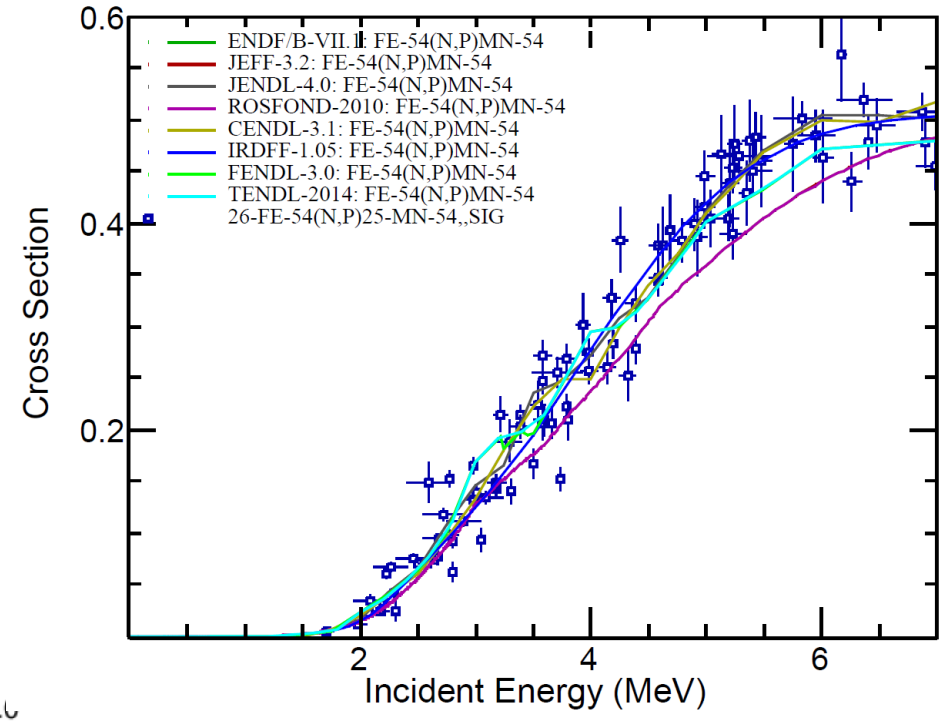
- Still, cross sections are unique quantities expressing probabilities (not like uncertainties)

Examples on dosimetry cross sections

Fe54(n,p)Mn54

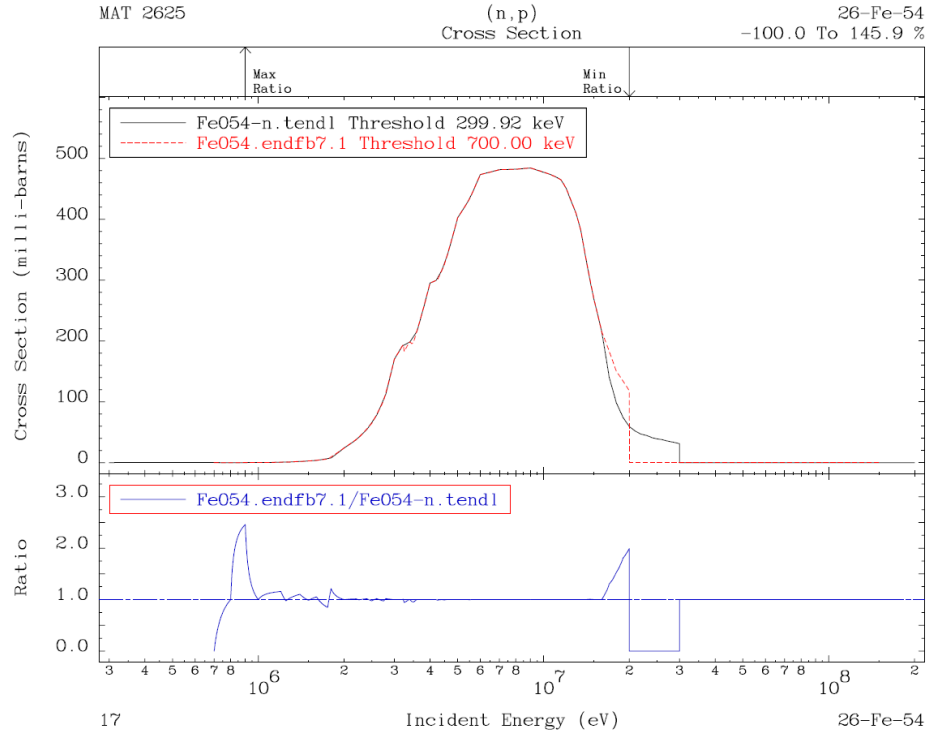


From JEFDOC-1593, NEA, November 2014

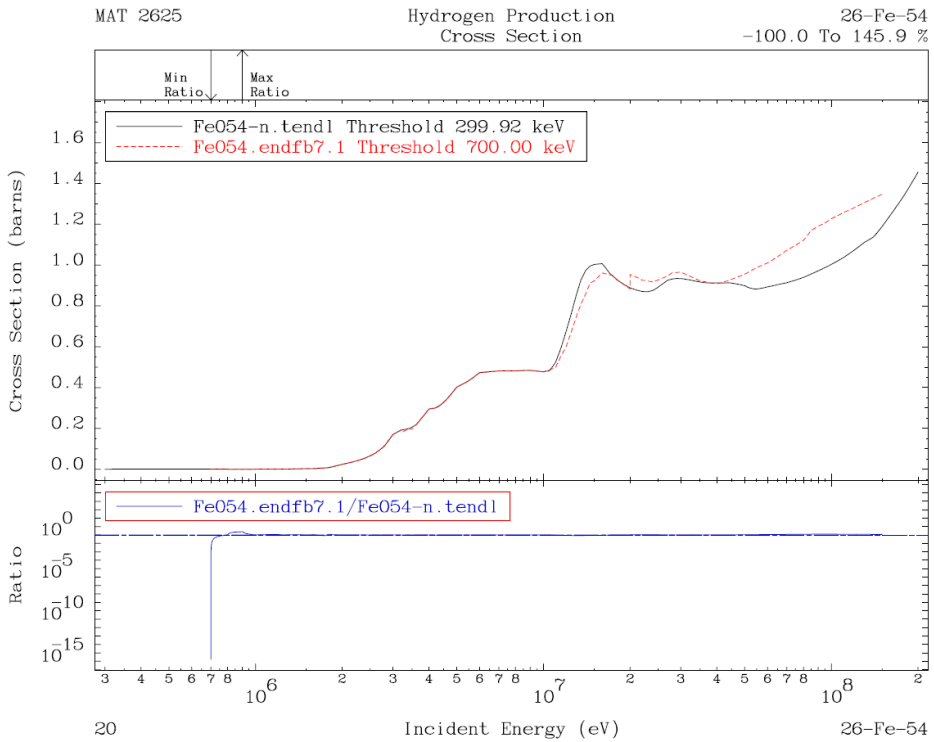


Examples on dosimetry cross sections

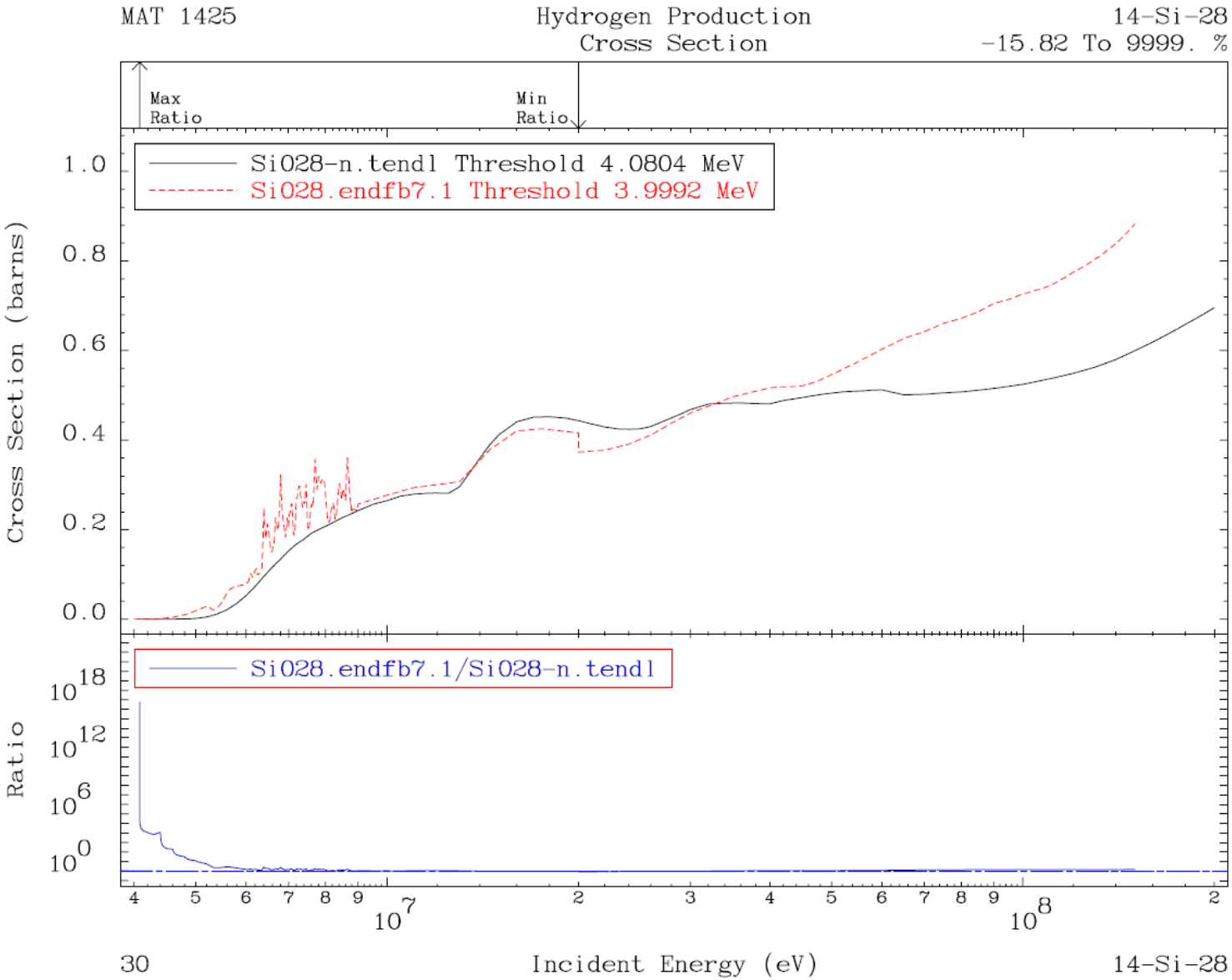
Fe54(n,p)



Fe54 p (or hydrogen) production



Examples on dosimetry cross sections: Si-28

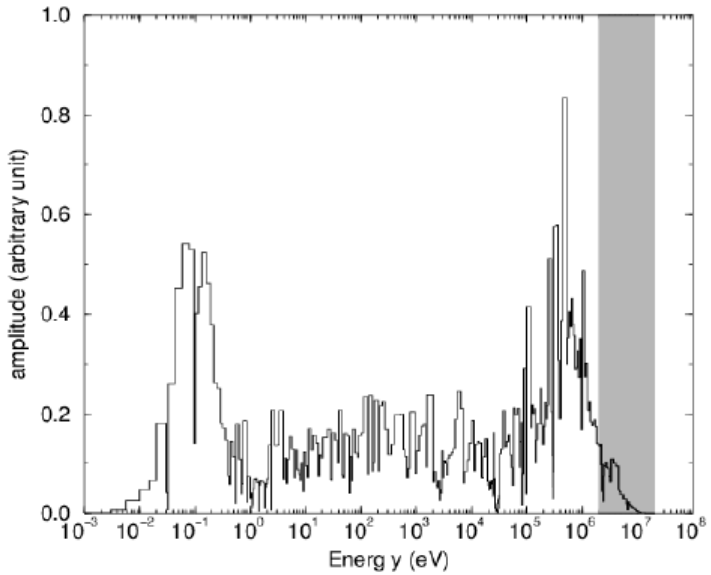


Examples on dosimetry cross sections

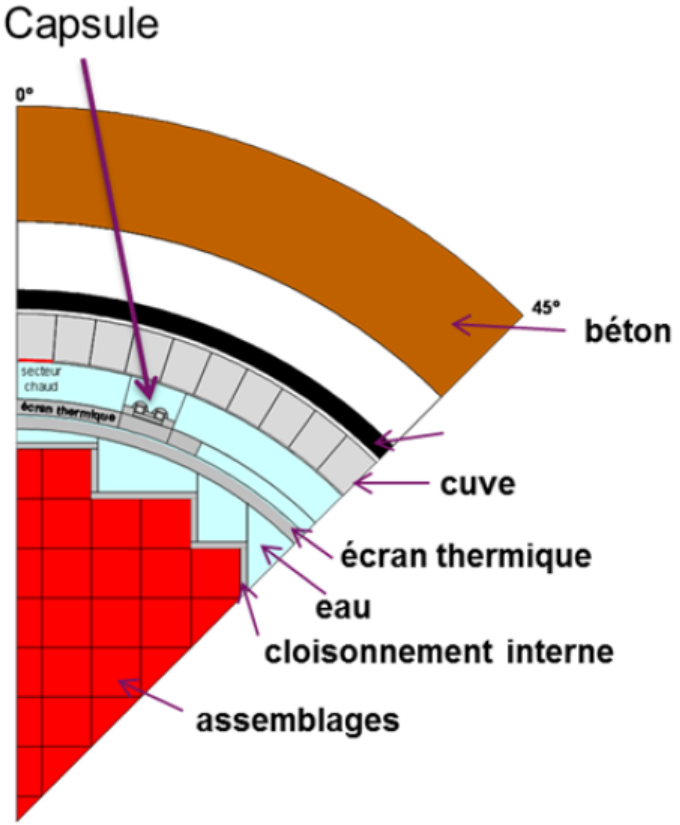
Large discrepencies between JEFF-32 (=JEFF-311) and IRDFF-1.04

Impact on activation calculations

Fe54(n,p)Mn54



Ratio	Result
IRDFF-1.04/EXFOR	0.99(2)
JEFF-32/EXFOR	0.91(2)



From JEFDOC-1593, NEA, November 2014

Examples on dosimetry cross sections

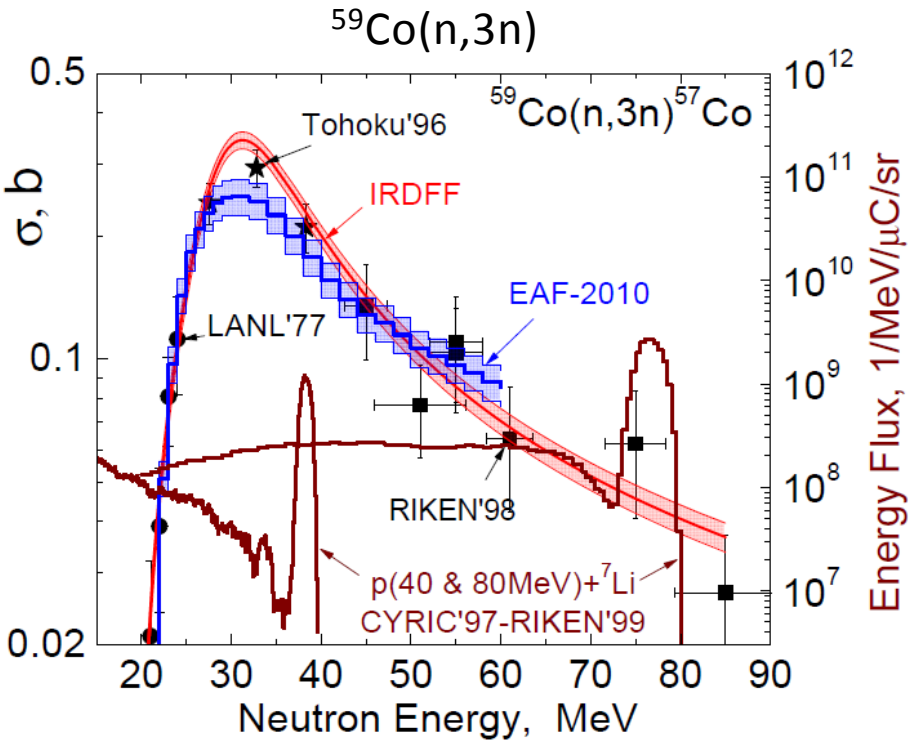
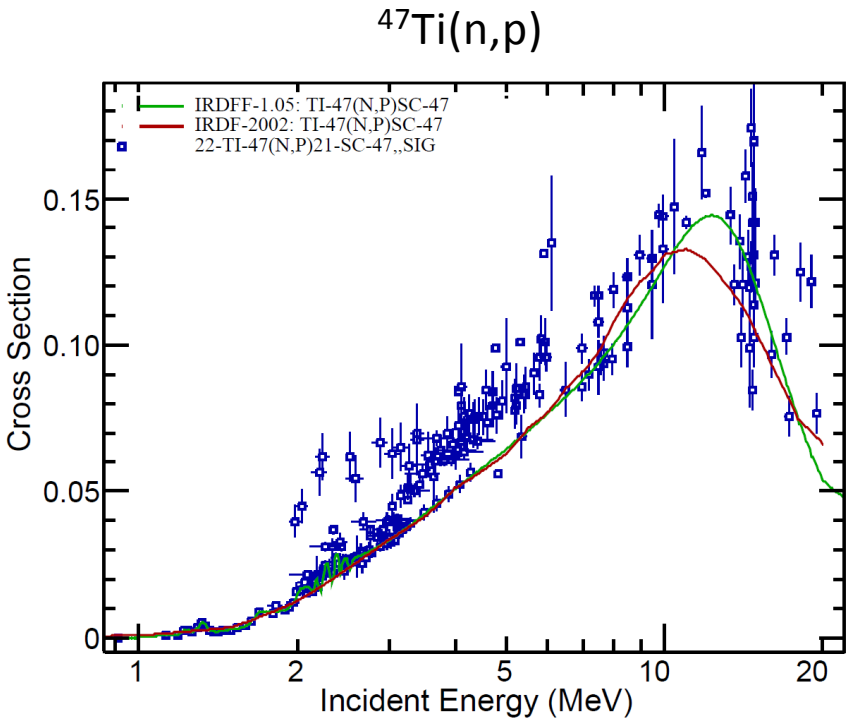


Figure 1. Experimental (EXFOR) and evaluated cross sections for ^{59}Co(n,3n) reaction and p-^{7}Li source spectra [8].

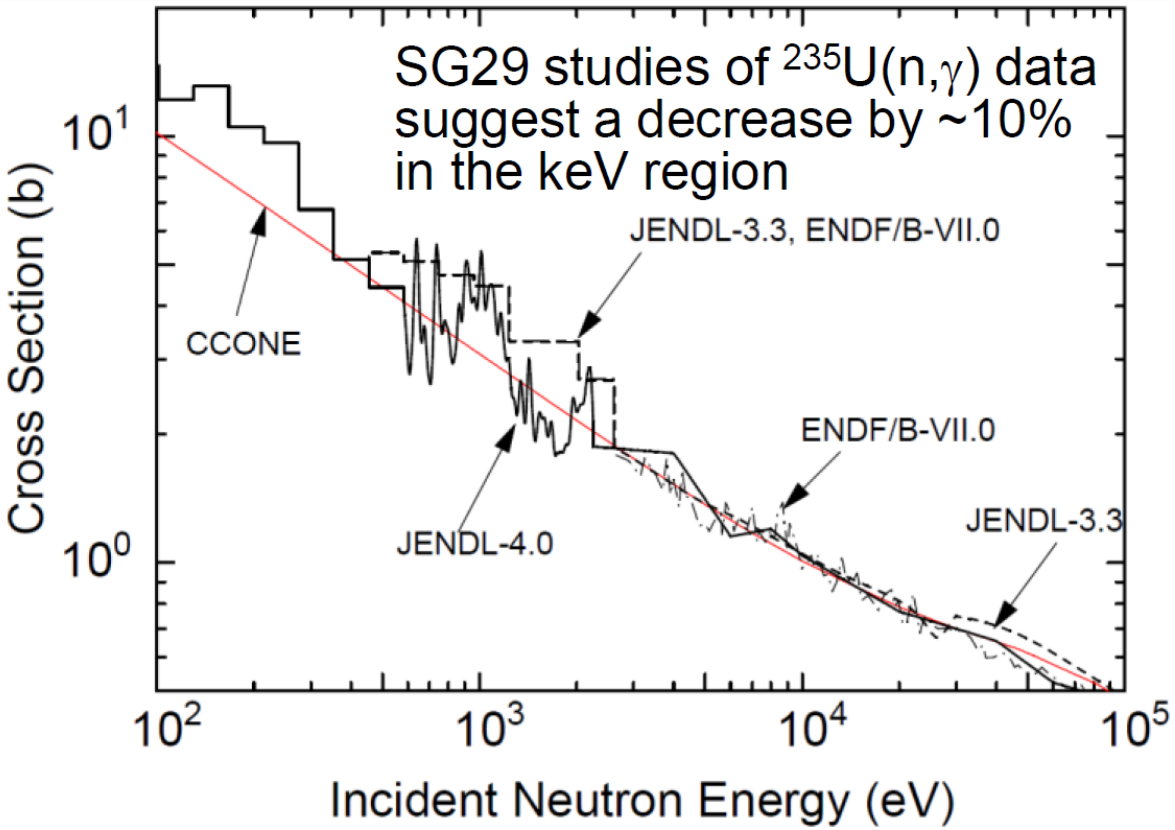
From Progress in Nuclear Science and Technology 4 (2014) 591

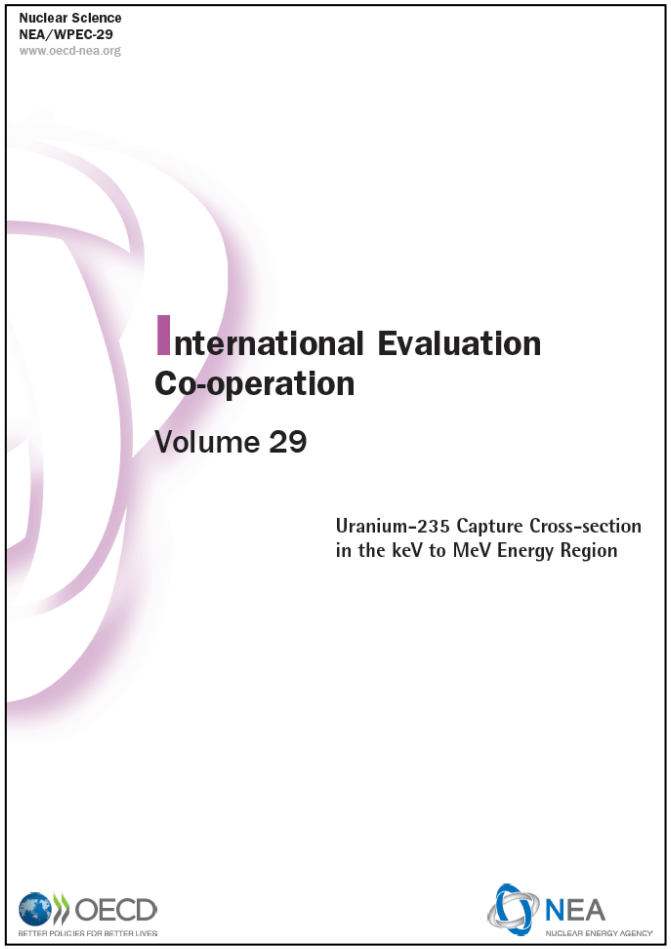


Among the activation/dosimetry libraries: important change/differences

Examples for important reactor cross sections

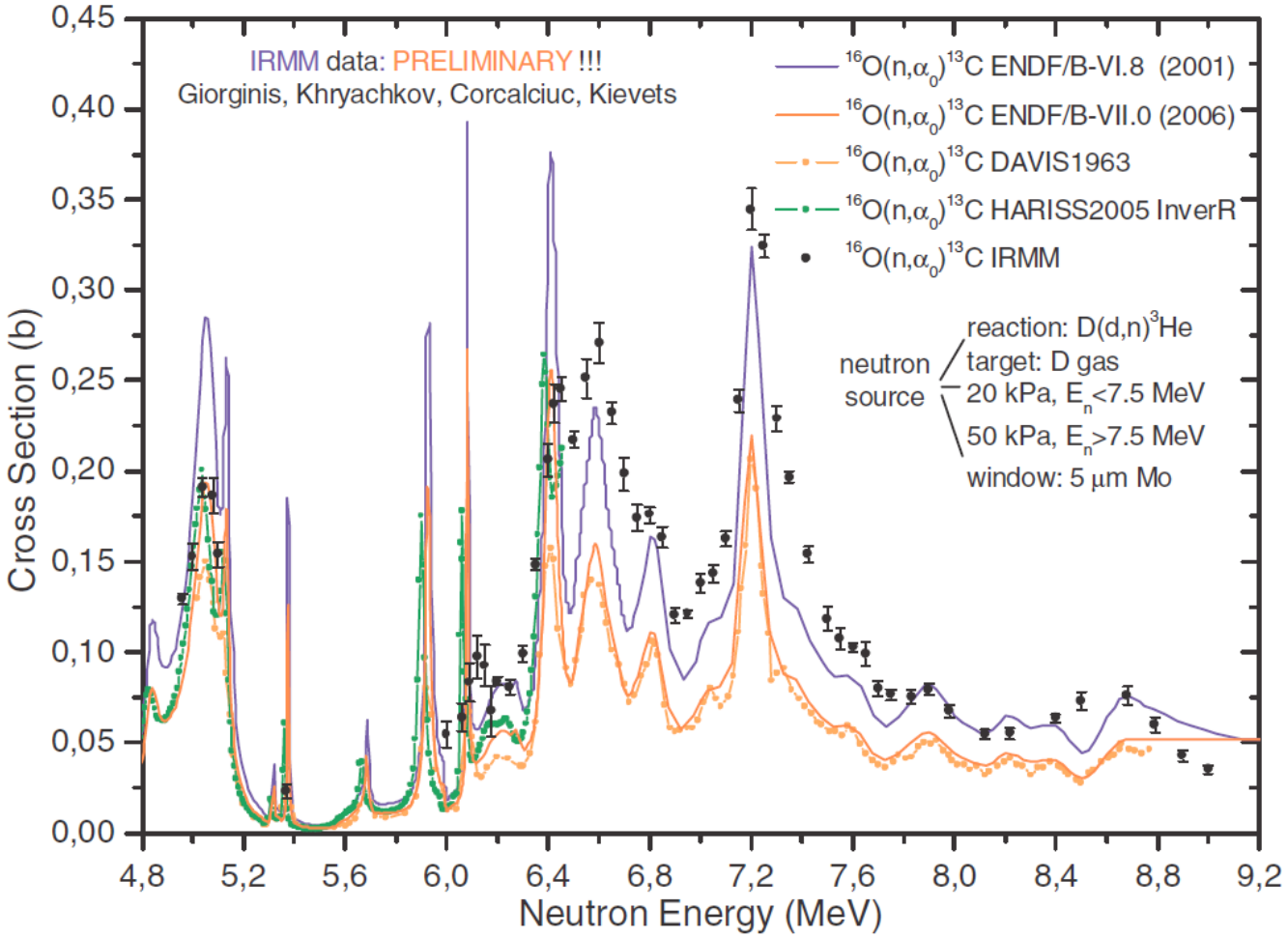
- Famous $^{235}U(n,g)$ cross section in the keV range





Examples for important reactor cross sections

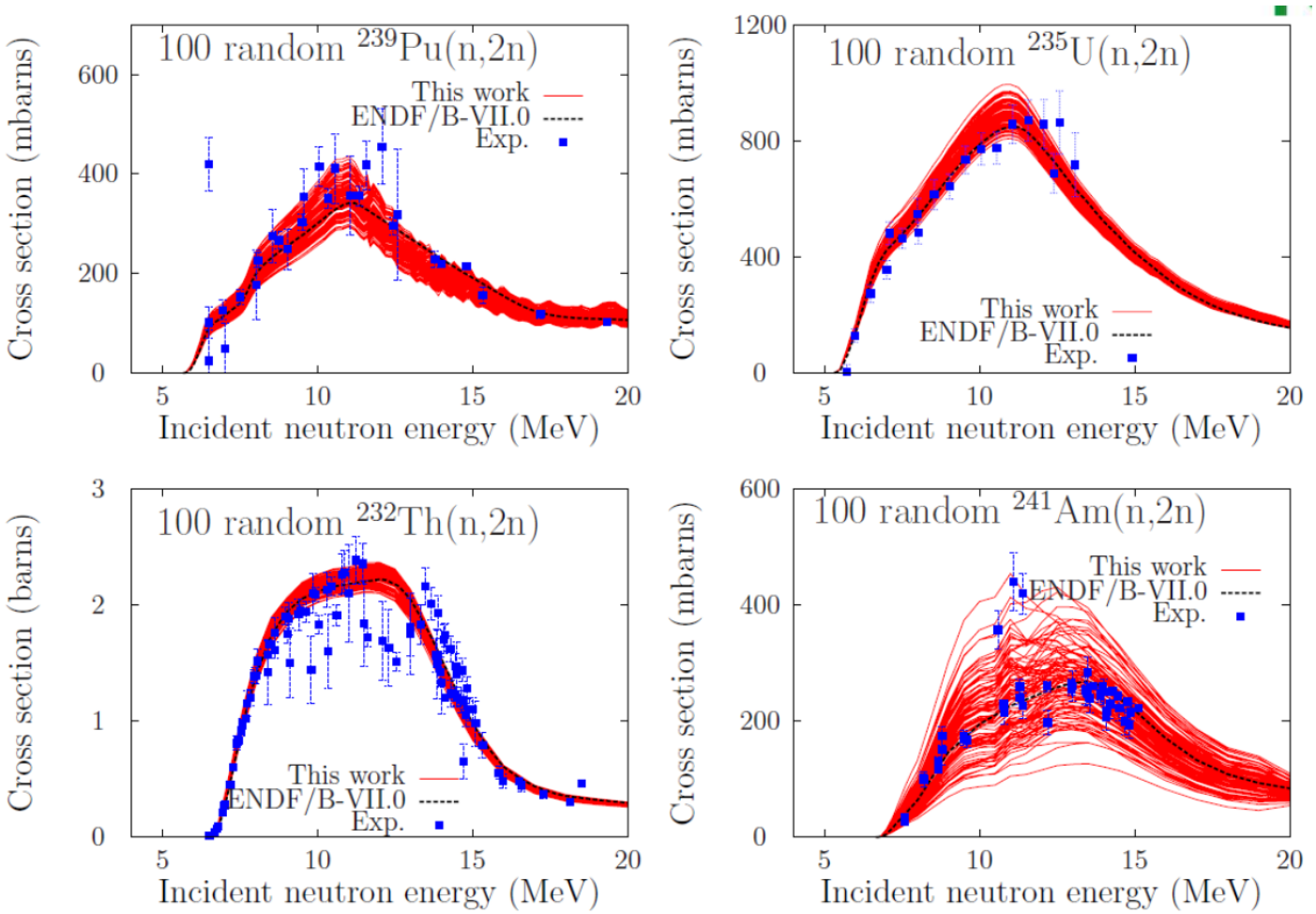
- ^{16}O(n,a) cross section, long standing problem, soon resolved



From http://dx.doi.org/10.1051/ndata:07481

Modeling: another source of uncertainties

- Models and theoretical calculations are necessary for cross section evaluations
- Without experimental data, microscopic/macroscopic calculations are still too blind for the required accuracy

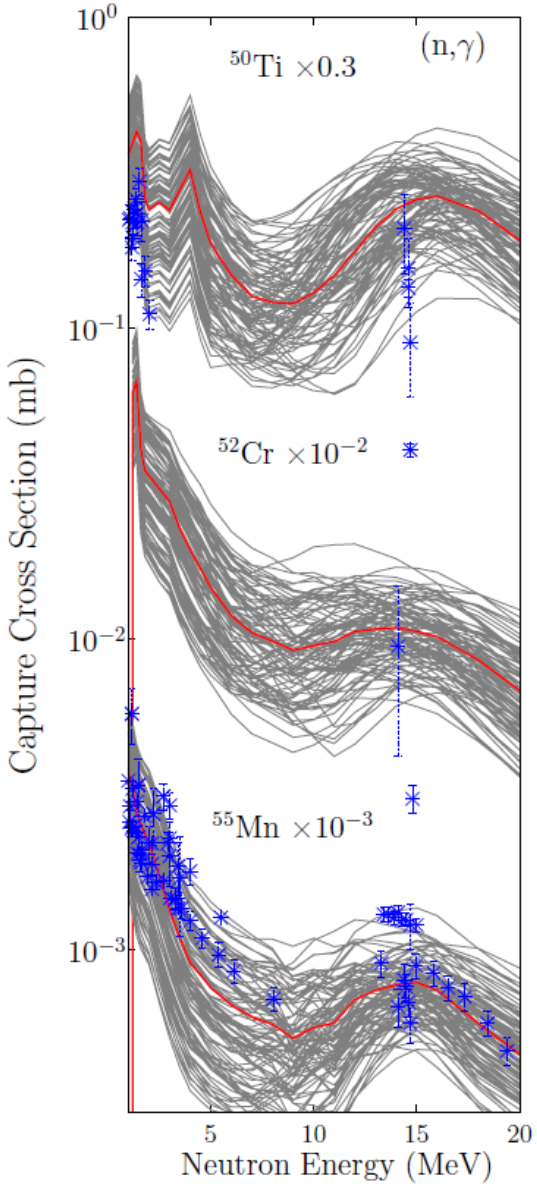


Modeling: another source of uncertainties

- Different models will lead to different cross sections
- Different persons with the same model will lead to different cross sections

- Current approach to express the spread of data: covariance files or TMC
  - Covariance files: uncertainties + correlations for cross sections
  - TMC: model parameter "pdf" (probability density function)

- Both approach have advantages and drawbacks



Conclusion

- Cross section evaluation below 20/200 MeV are based on measurements,
- Cross section evaluation below 20/200 MeV are complemented by modeling,
- Both are not well known and approximate,

- Many important cross sections are (too) uncertain,
- A current effort in the nuclear data community focusses on uncertainty estimation,
- As a conclusion, cross sections are still better represented by pdf* than by unique values.

pdf: probability density functions

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Wir schaffen Wissen – heute für morgen