Progress on ^{238}U(n,f) cross section evaluation for CENDL

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CNDC CHINA NUCLEAR DATA CENTER

Contents

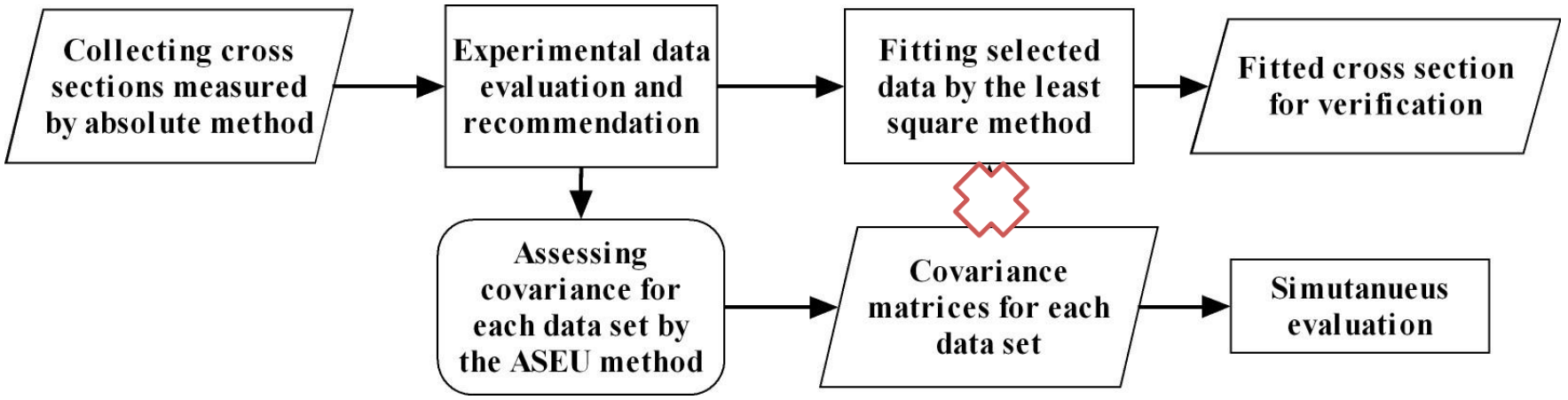
- Background
- Evaluation procedure
- Selection of experimental data for ^{238}U(n,f) reaction
- Comparison of evaluated U-238(n,f) cross section
- Comparison of evaluated covariance
- Discussion

Background

- **CENDL-2 and CENDL-3.1**
  - U-238 (n,f) cross sections were evaluated based on the absolute measured experimental data of U-238(n,f) and the cross section ratio of U-238(n,f)/U-235(n,f) reaction.
    - **Absolute data were convert to ratio data and fitted together with the experimental ratio data.**
  - From 0.10 to 20 MeV, U-235(n,f) cross section was standard evaluation by the CSEWG Standards Committee

- **Next CENDL**
  - Simultaneous evaluation of cross sections of ^{235}U(n,f), ^{235}U(n,γ), ^{238}U(n,f), ^{238}U(n,γ) and et al. reactions are expected to be used.
  - Evaluating cross sections measured by the absolute methods and assessing covariance for each data set is an important step before simultaneous evaluation.

Evaluation procedure



Analysis of Source of Experimental Uncertainty (ASEU)

Measured Quantity:

$$y = f(x_1, x_2, \mathrm{L}\ x_N)$$

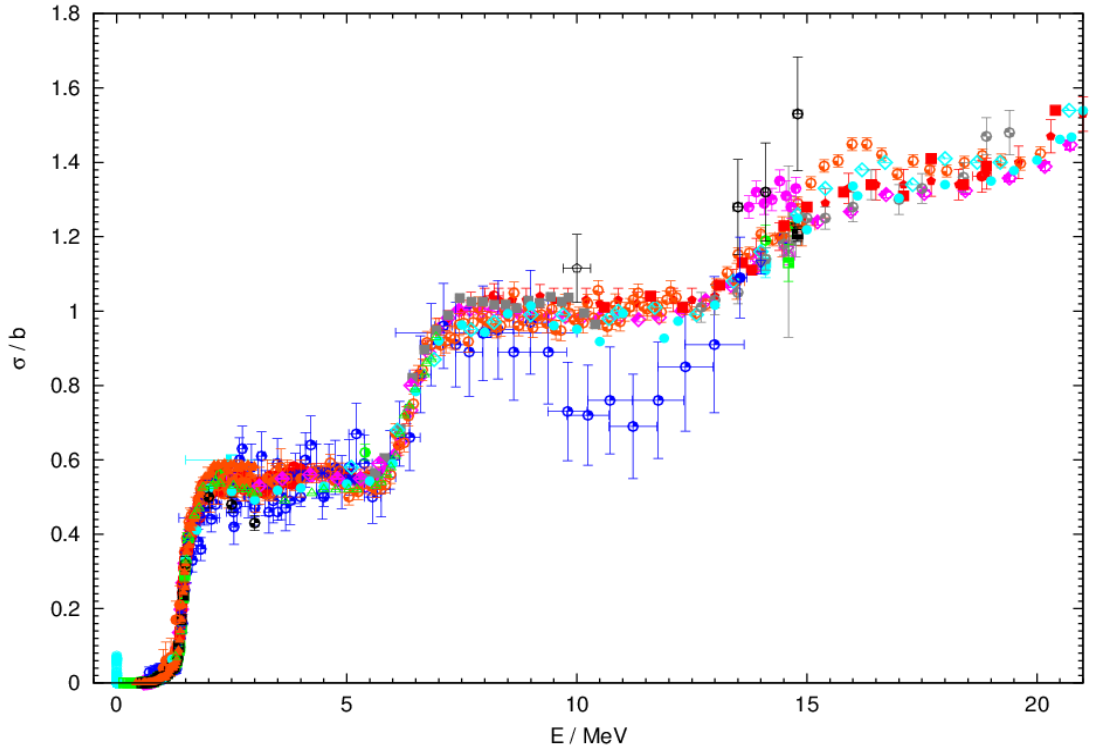
$$Cov(y_i, y_j) = \left\langle \left(\sum_{k=1}^{N} \frac{\partial f}{\partial x_k}\Big|_i \Delta x_{ki} \right) \left(\sum_{k'=1}^{N} \frac{\partial f}{\partial x_j}\Big|_i \Delta x_{k'j} \right) \right\rangle$$

$$= \sum_{kk'}^{N} \rho_{ij}^{kk'} \left(\frac{\partial f}{\partial x_k}\Big|_i \Delta x_{ki} \right) \left(\frac{\partial f}{\partial x_j}\Big|_i \Delta x_{k'j} \right)$$

$$= \sum_{kk'}^{N} \rho_{ij}^{kk'} \Delta y_{ki} \Delta y_{k'j}$$

Selection of experimental data for ^{238}U(n,f) reaction

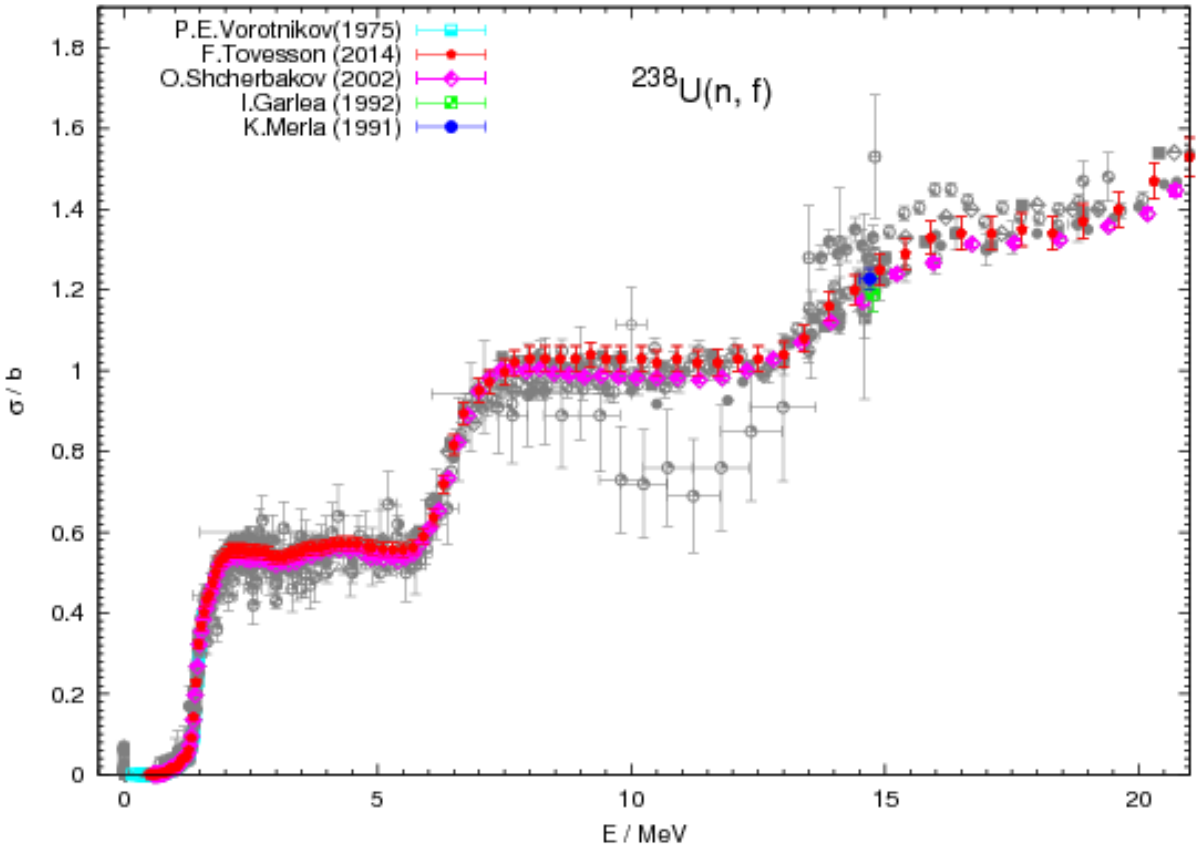
- **Absolute Measurements of ^{238}U(n,f) cross section in EXFOR**
  - 47 entries: from 1948 to 2014; E_n from 7e-4 to 380MeV
  - Only data between 0.5 and 20MeV were consider.



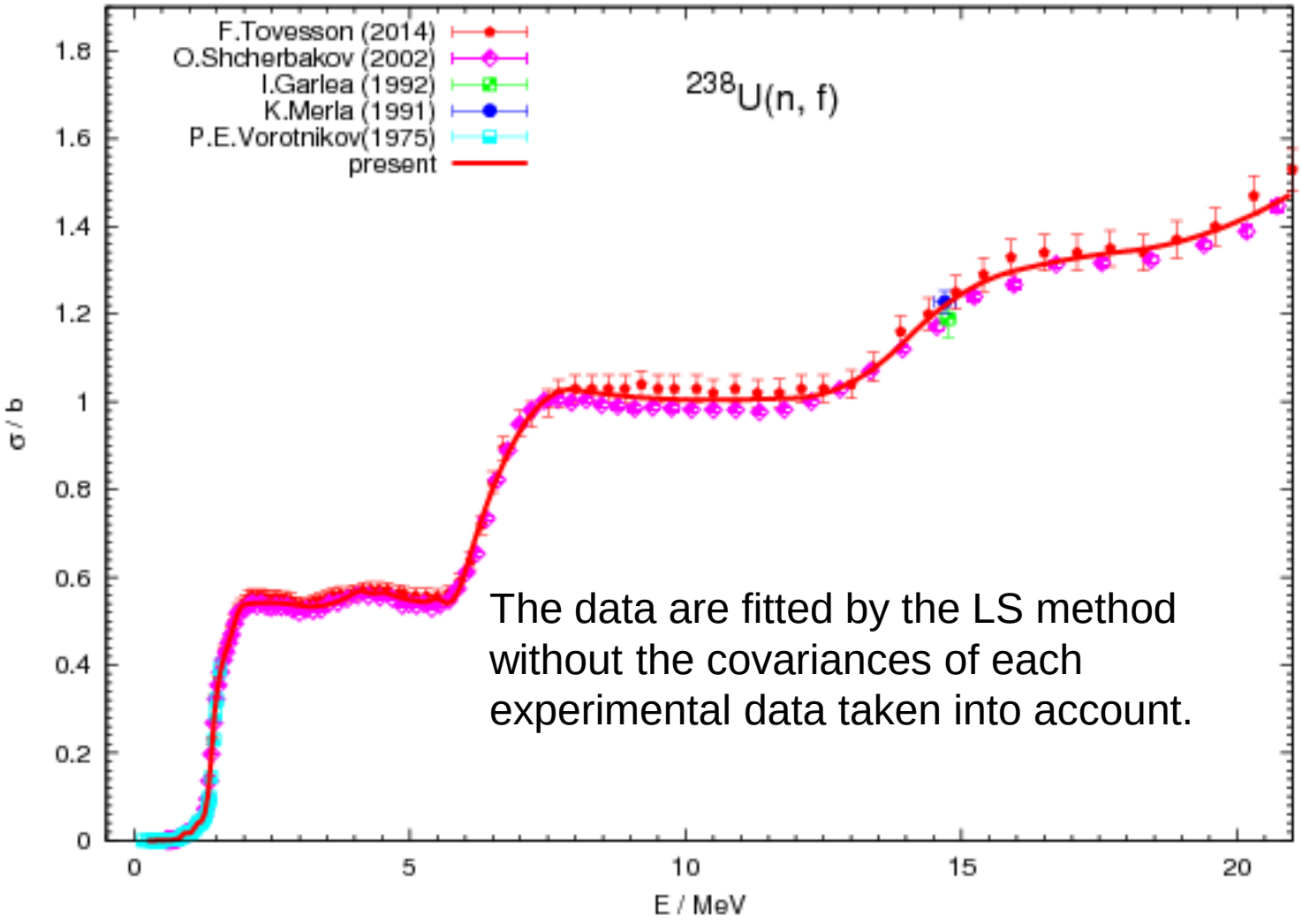
experimental data of ^{238}U(n,f) cross section below 20MeV

- **Only a few data sets with good quality should be used for the following evaluation**
  - 5 data sets which measured with better experimental conditions, such as neutron source, sample, detector, uncertainty and et al., were selected as representative.

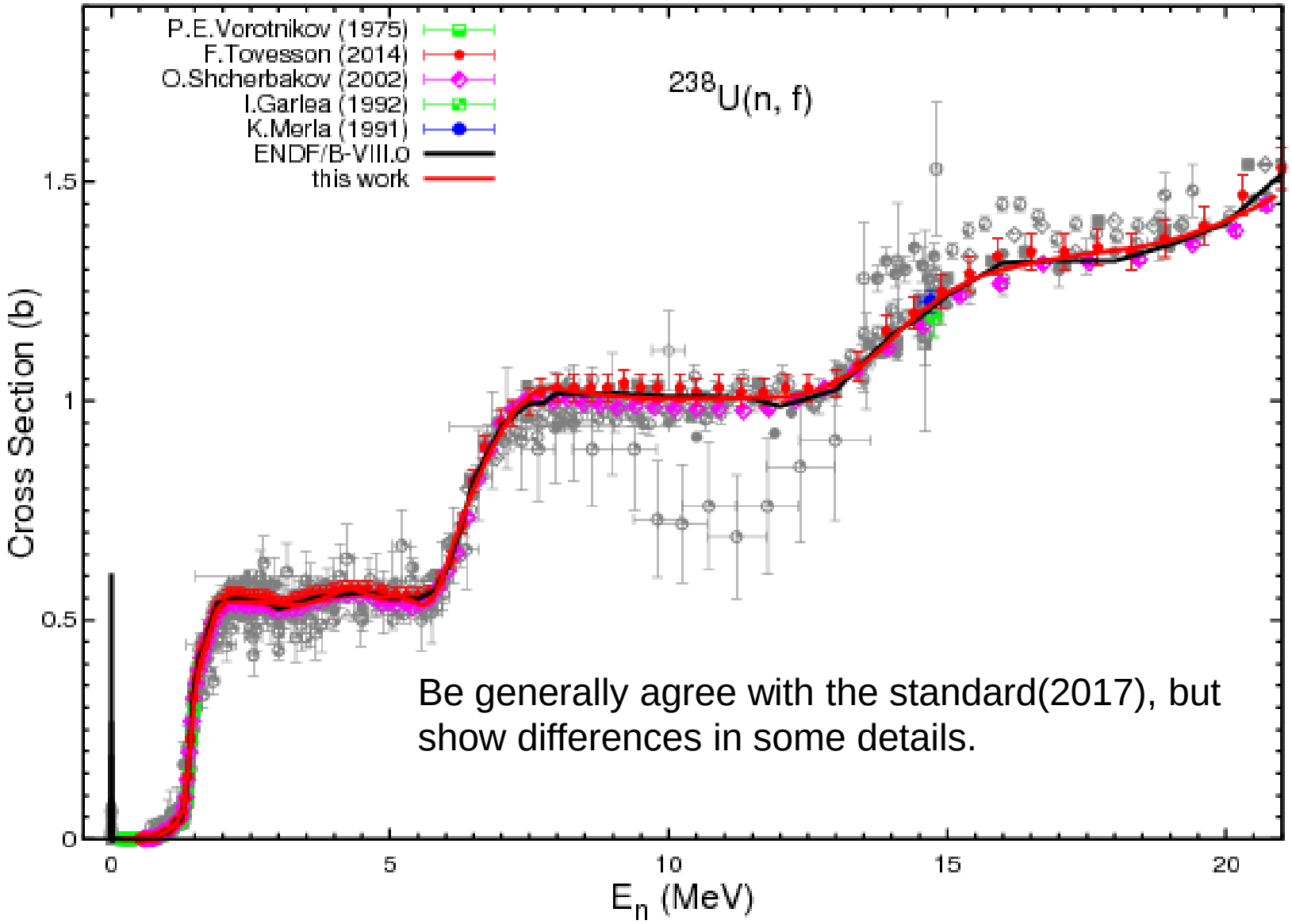
- E_n<1MeV,1 one data set;
- 1<E_n<20MeV, 4 data sets;
- 2 data sets around 14MeV.

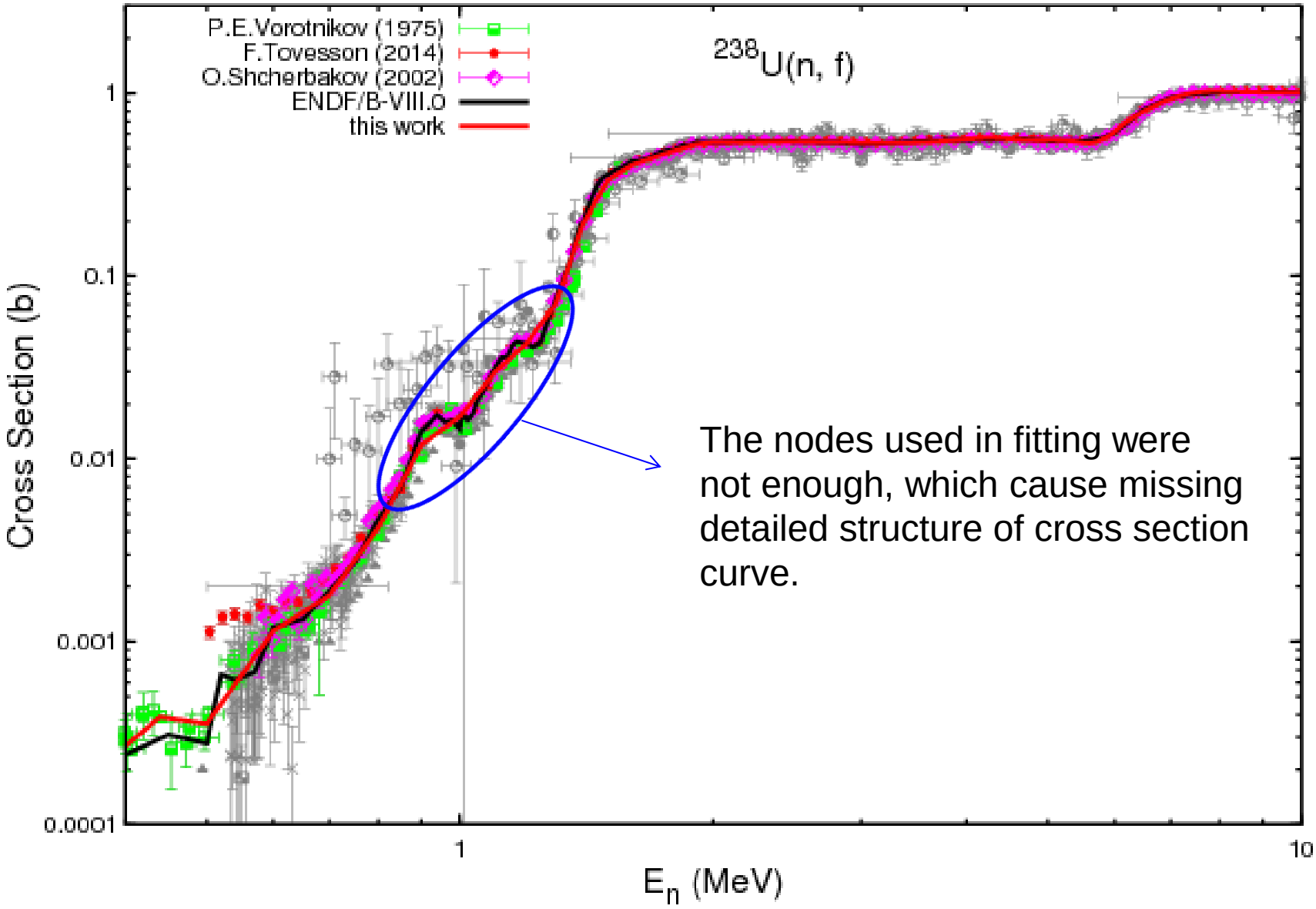


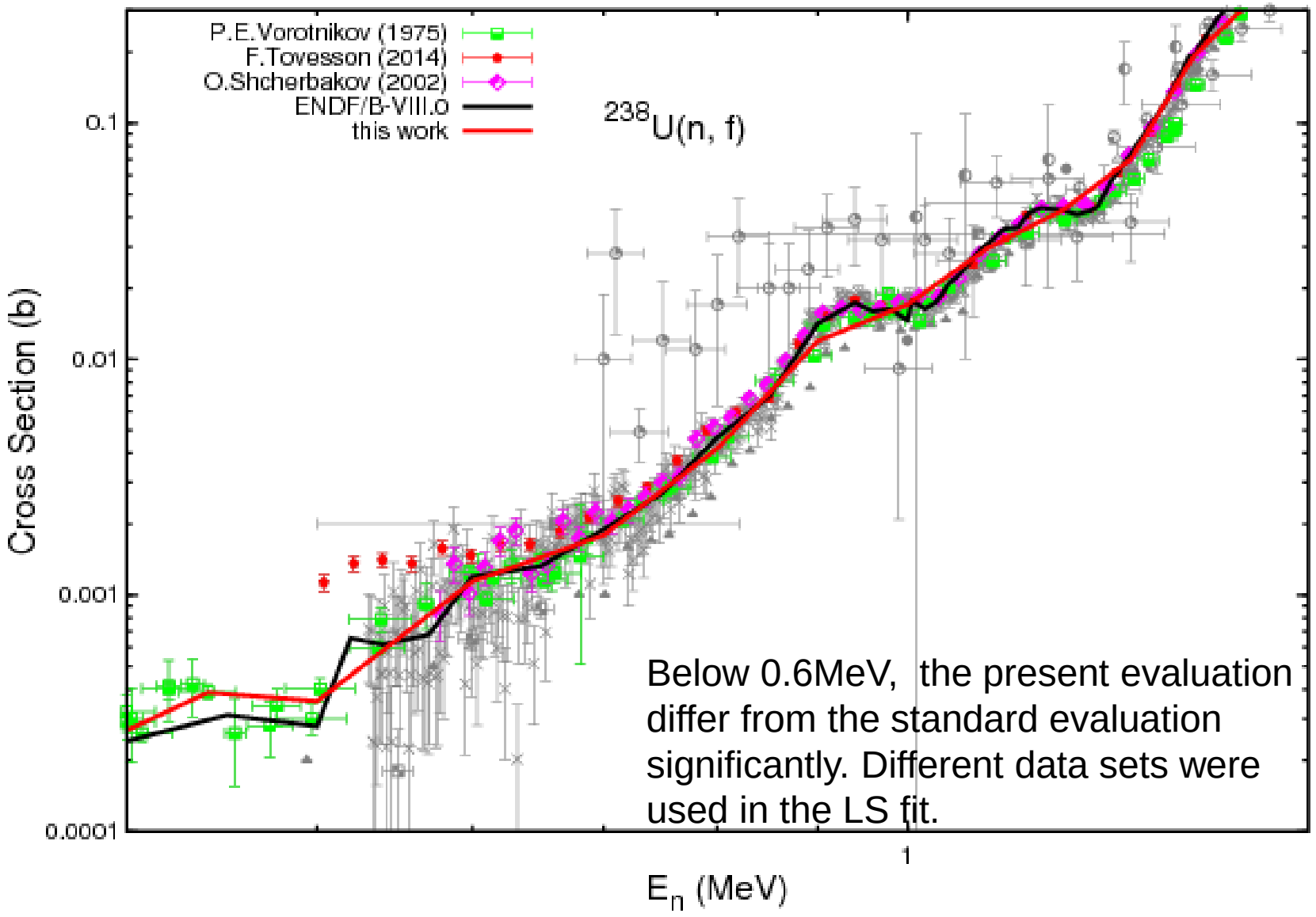
Comparison of evaluated U-238(n,f) cross sections



The data are fitted by the LS method without the covariances of each experimental data taken into account.


P.E.Vorotnikov (1975)
F.Tovesson (2014)
O.Shcherbakov (2002)
I.Garlea (1992)
K.Merla (1991)
ENDF/B-VIII.0
this work
^{238}U(n, f)
Cross Section (b)
E$_n$ (MeV)
0
0.5
1
1.5
0
5
10
15
20
Be generally agree with the standard(2017), but show differences in some details.


P.E.Vorotnikov (1975)
F.Tovesson (2014)
O.Shcherbakov (2002)
ENDF/B-VIII.0
this work
^{238}U(n, f)
Cross Section (b)
1
0.1
0.01
0.001
0.0001
1
10
E_n (MeV)
The nodes used in fitting were not enough, which cause missing detailed structure of cross section curve.


P.E.Vorotnikov (1975)
F.Tovesson (2014)
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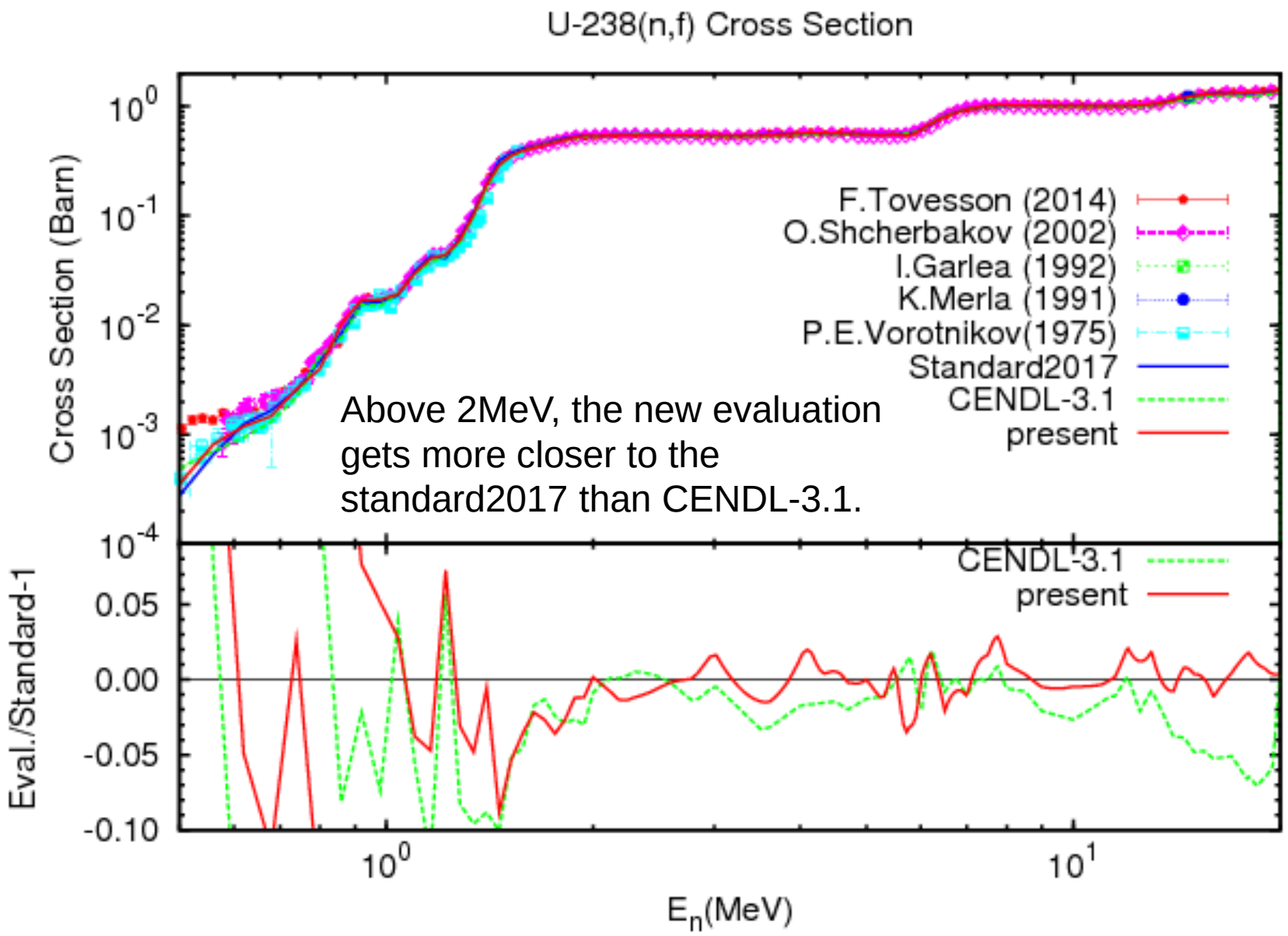
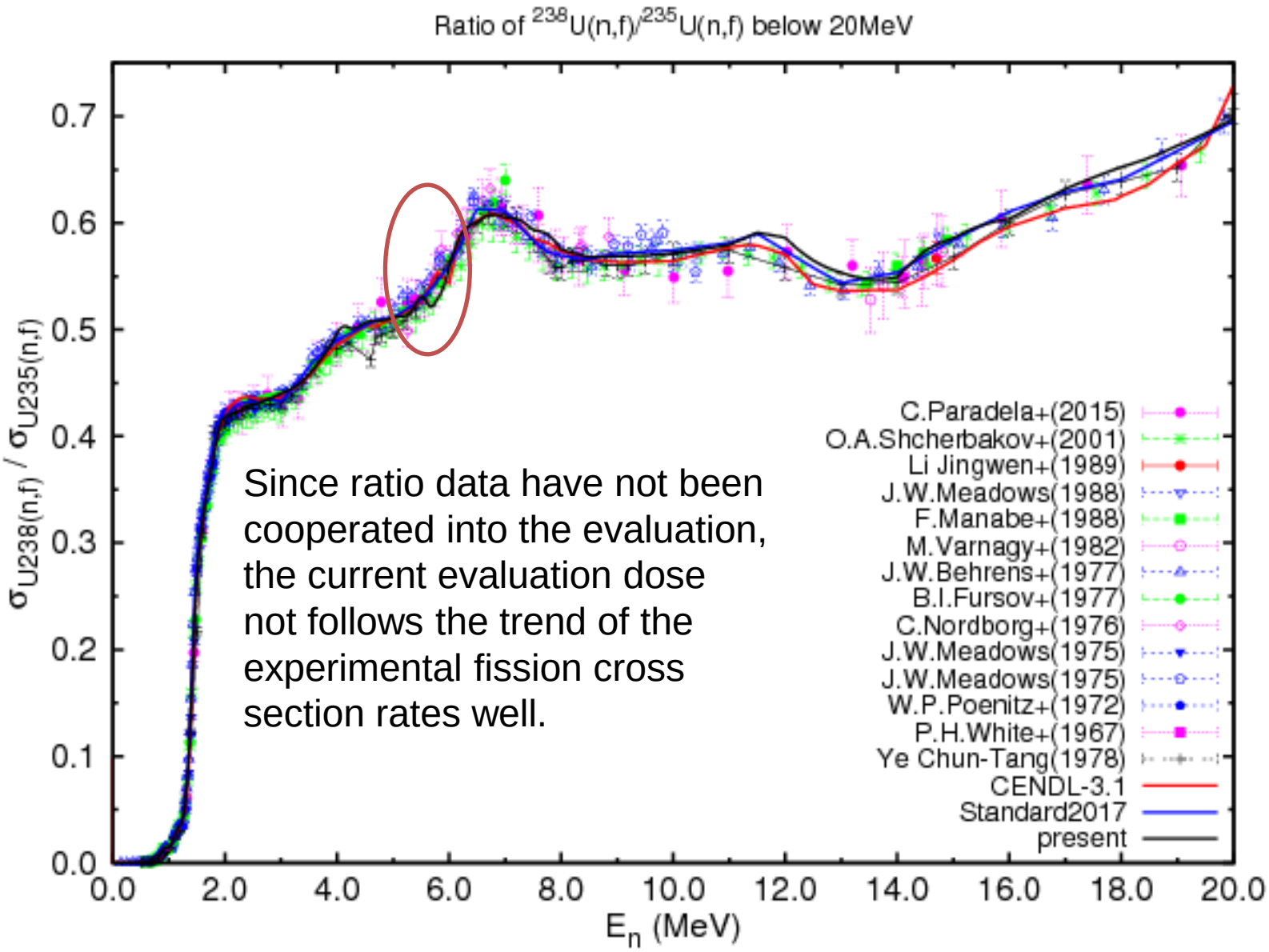
ENDF/B-VIII.0
this work
^{238}U(n, f)
Cross Section (b)
0.1
0.01
0.001
0.0001
1
E_n (MeV)
Below 0.6MeV, the present evaluation differ from the standard evaluation significantly. Different data sets were used in the LS fit.

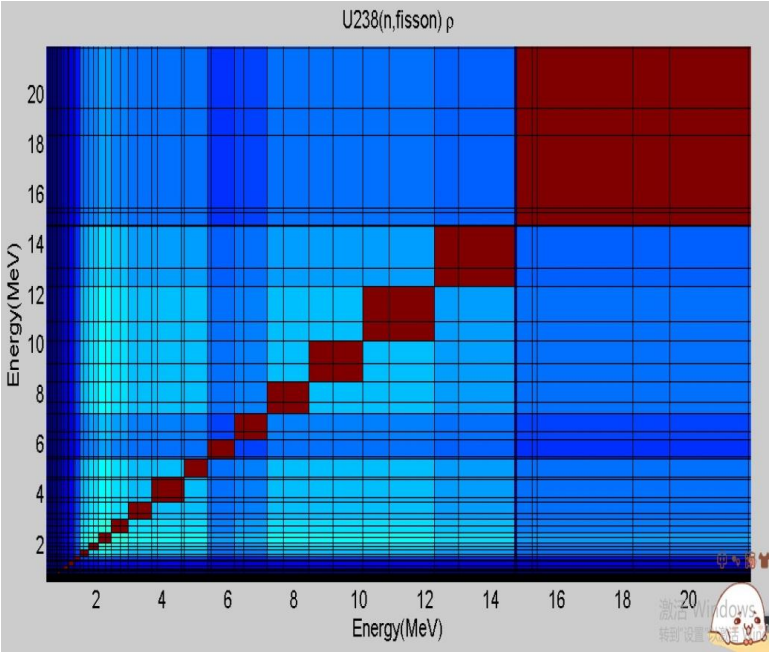

U-238(n,f) Cross Section
Cross Section (Barn)
F.Tovesson (2014)
O.Shcherbakov (2002)
I.Garlea (1992)
K.Merla (1991)
P.E.Vorotnikov(1975)
Standard2017
CENDL-3.1
present
Above 2MeV, the new evaluation gets more closer to the standard2017 than CENDL-3.1.
Eval./Standard-1
CENDL-3.1
present
E_n(MeV)

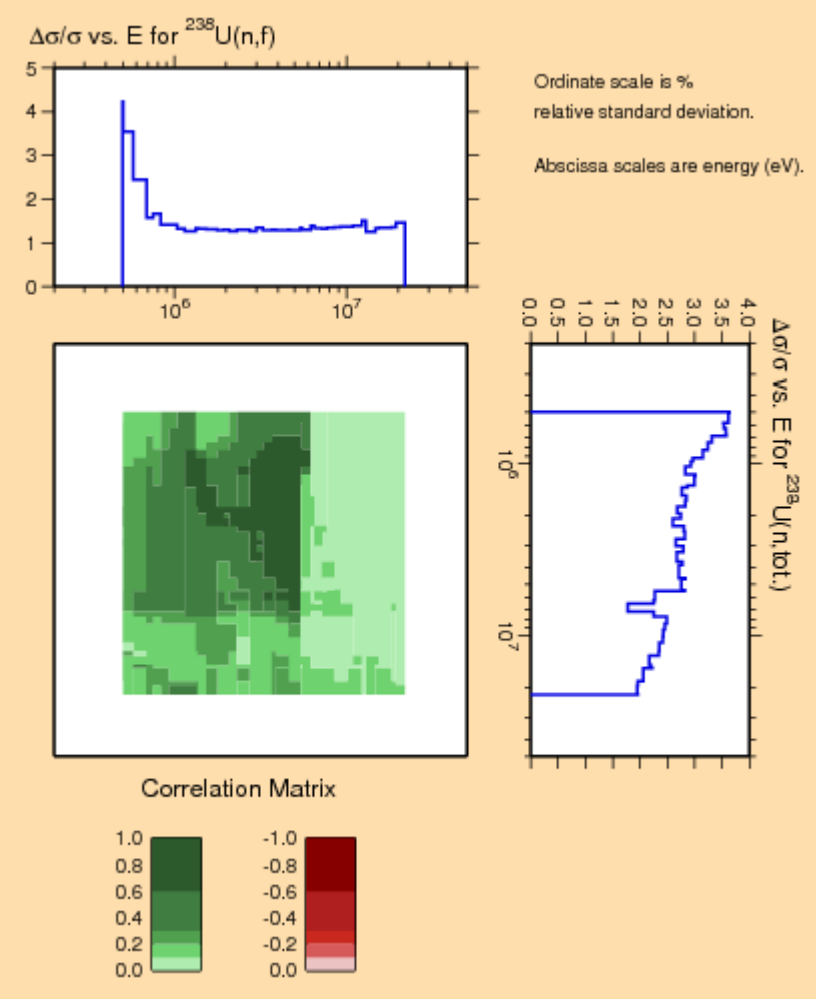


Since ratio data have not been cooperated into the evaluation, the current evaluation dose not follows the trend of the experimental fission cross section rates well.

Comparison of evaluated covariance

- Covariance matrices for each data set were constructed based the uncertainty information given by the author.
- After processed by ASEU-2.0 code , positive matrix of correlation coefficients were obtained.





Discussion

- **Does the current selection of experimental data is enough?**
- **Is it a proper way that do the LS fit without using covariance data from experiments?**
- **How to judge if the evaluation of covariance for each data set is reasonable?**

Thank you for your attention !