Checking RRR in EXFOR

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NRDC 2017, 23-26 May 2017
IAEA Headquarters (Room C0234), Vienna, Austria

1. NEA activities in 2016

- **SCM´s Methodology (**JEF/DOC-1778, Nov 2016**)**

   1) Def. "distance" is the interval between two 95% vertical confidence intervals
   2) Compute the min distance over the discretized horizontal confidence interval

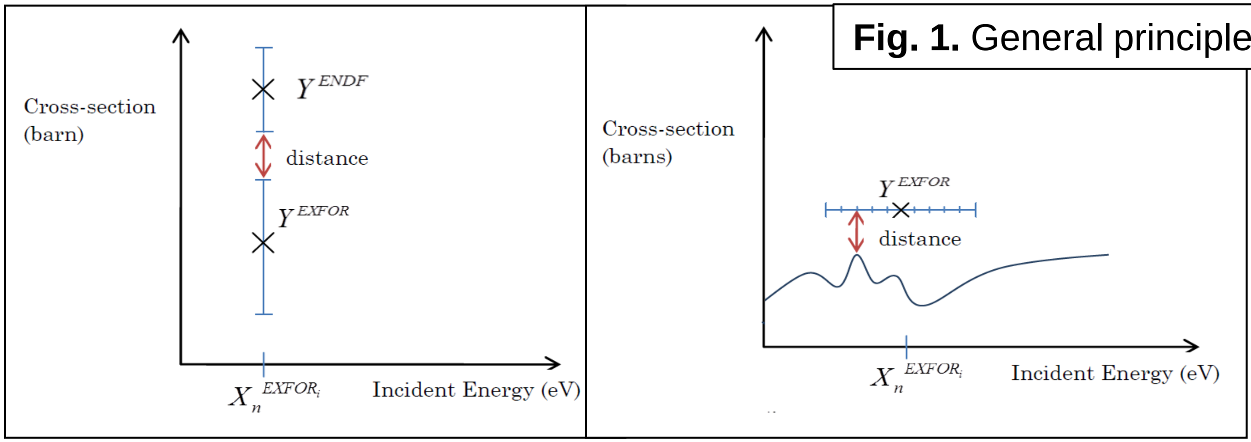


Fig. 1. General principle of the method

   3) Def. "Rank value" to identify the potential problems in EXFOR or ENDF:

$$\text{ratio} = \frac{\text{distance}}{\max(\sigma_{EXFOR}, \sigma_{ENDF})}$$

- The higher the ratio the higher the disagreement
- The ratio is averaged for all the EXFOR points
- *Potential outliers*
  - $rank = \text{"D"}$, if $ratio \in]3, 8]$
  - $rank = \text{"E"}$, if $ratio > 8$

❑ Implementation SCM´s Methodology

1) Finding the right scale for abscissa and discretizing it in **50 intervals**

2) Constructing the **resonance indicator** as the "relative variance"

3) Computing the distance ratios for each intervals

❑ **In a no-resonance interval:** $\text{ratio\_interval} = \frac{1}{N}\sum_{i=1}^{N} \frac{\text{distance}_i}{\max(\sigma_i^{EXFOR}, \sigma^{ENDF})}$

where

N is the total number of points in the interval

σ is the standard deviation

distance_i is the distance between the EXFOR point i and the ENDF curve

❑ **In a resonance interval:** $\text{ratio\_interval} = \frac{|\bar{Y}_{ENDF} - \bar{Y}_{EXFOR}|}{\max(\bar{\sigma}_{ENDF}, \bar{\sigma}_{EXFOR})}$

where

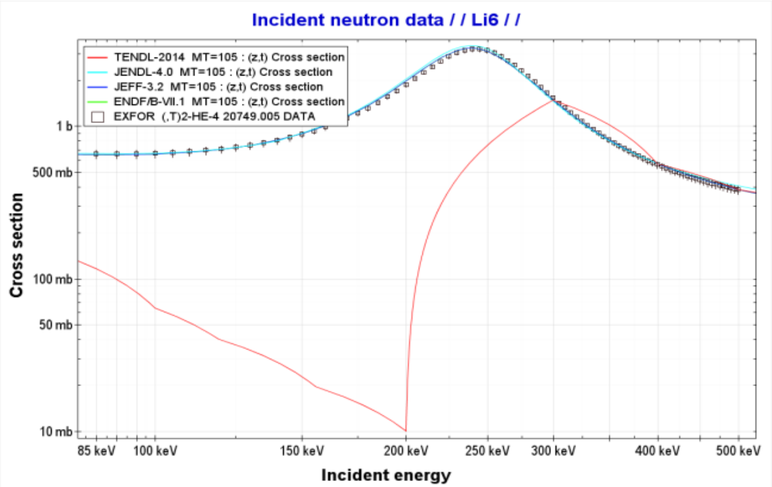
$$\bar{Y}^{\text{EXFOR or ENDF}} = \frac{1}{10}\sum_{j=1}^{10}\frac{1}{N_j}\sum_{i=1}^{N_j} Y_i^{\text{EXFOR or ENDF}},$$

❑ Results

Among the 26,634 subentries checked:

- Ratio > 3: 2,937 subentries;
- Ratio > 5: 1,932 subentries;
- Ratio > 10: 284 subentries;
- Ratio > 20: 45 subentries.

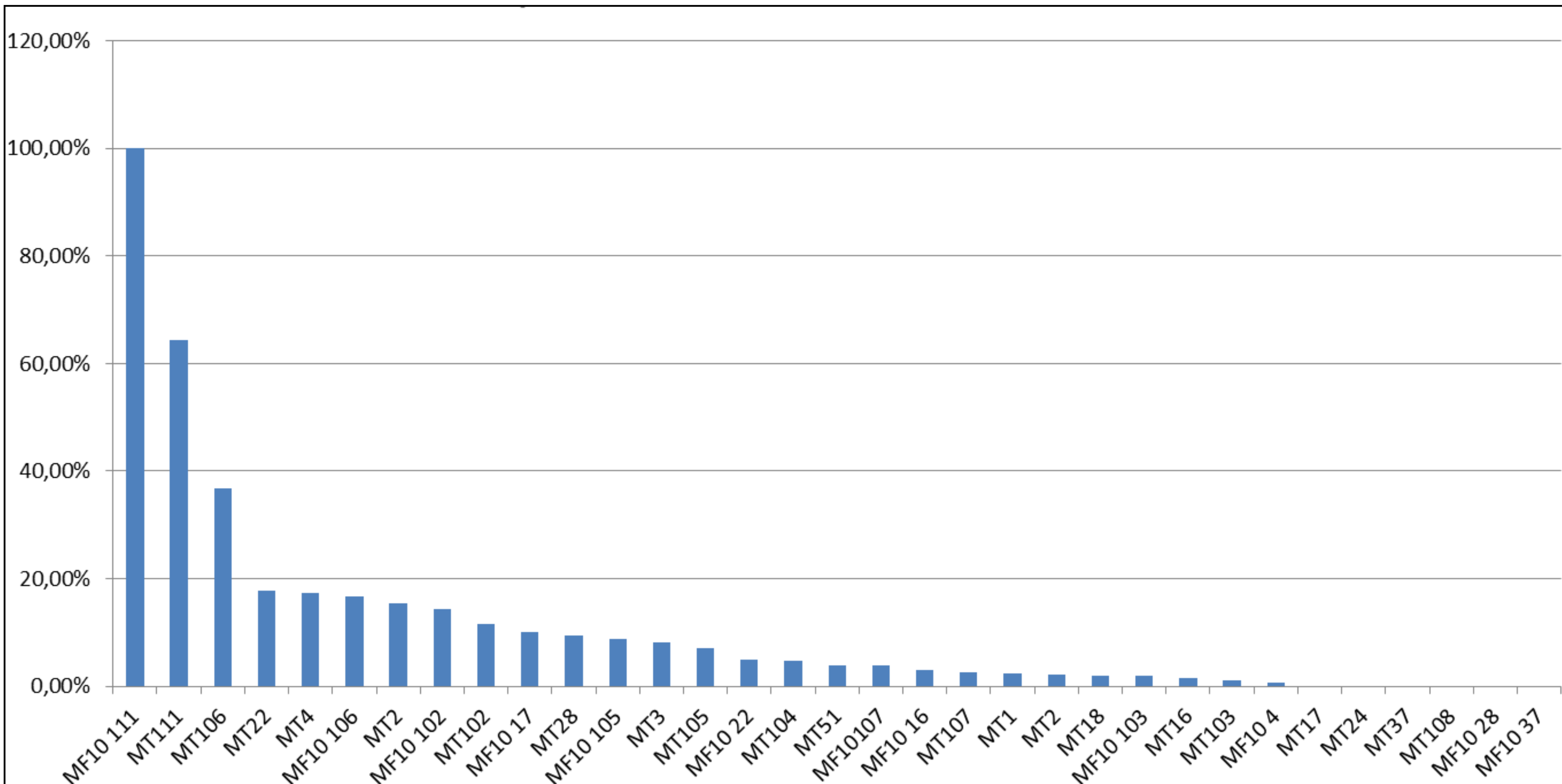
Only subentries that disagree with all evaluators are counted; situations like below are not included:



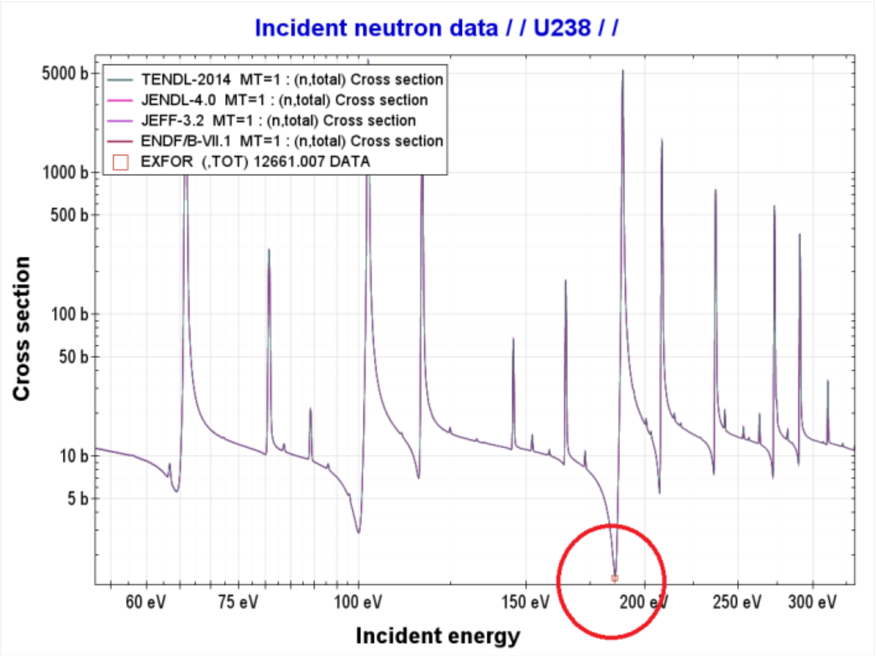
MF	MT	Number of subentries	Rank of D or E	D or E in (%)
3	(n,tot)	3742	142	3.8
3	(n,el)	1195	61	5.1
3	**(n,nonelastic)**	279	87	31.2
3	**(n,n)**	258	63	24.4
3	(n,2n)	1593	46	2.9
3	(n,3n)	66	0	0.0
3	(n,fission)	1440	45	3.1
3	**(n,nalpha)**	56	11	19.6
3	(n,2nalpha)	5	0	0.0
3	(n,np)	75	9	12.0
3	(n,nX)	3400	229	6.7
3	(n,n4)	28	2	7.1
3	(n,gamma)	3697	566	15.3
3	(n,p)	1913	29	1.5
3	(n,d)	43	2	4.7
3	(n,t)	157	16	10.2
3	**(n,He)**	38	15	39.5
3	(n,alpha)	1123	39	3.5
3	(n,2alpha)	4	0	0.0
3	**(n,2p)**	14	9	64.3
10	(n,n)	262	8	3.1
10	(n,2n)	1148	60	5.2
10	(n,3n)	20	4	20.0
10	(n,nalpha)	20	2	10.0
10	(n,np)	21	0	0.0
10	(n,n4)	3	0	0.0
10	**(n,gamma)**	496	113	22.8
10	(n,p)	690	29	4.2
10	(n,t)	45	5	11.1
10	(n,He)	6	1	16.7
10	(n,alpha)	310	25	8.1
10	(n,2p)	1	1	100.0
4	(n,el)	4549	1099	24.2

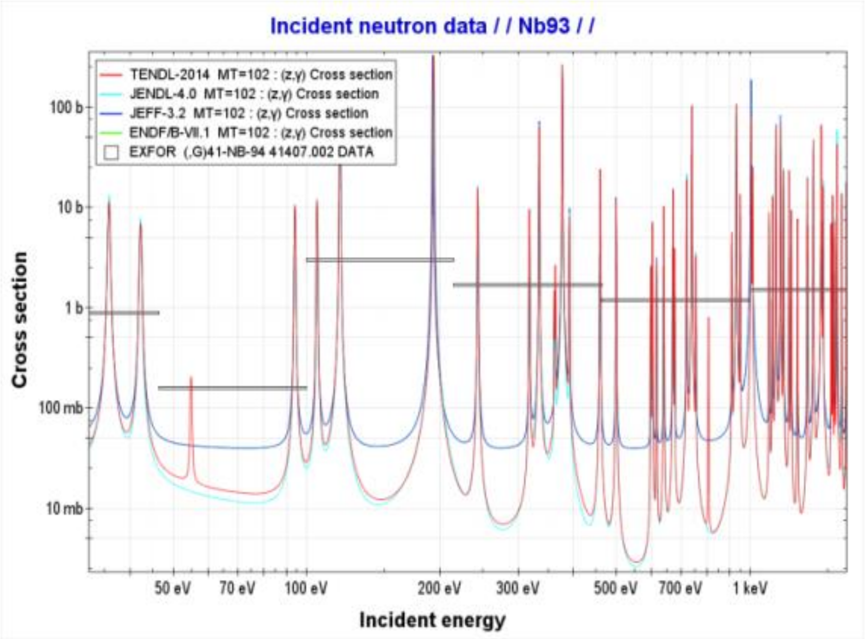
❑ Results

Fig. 2. Proportion of subentries with ratio>5 for all reaction (from the worst to the best)

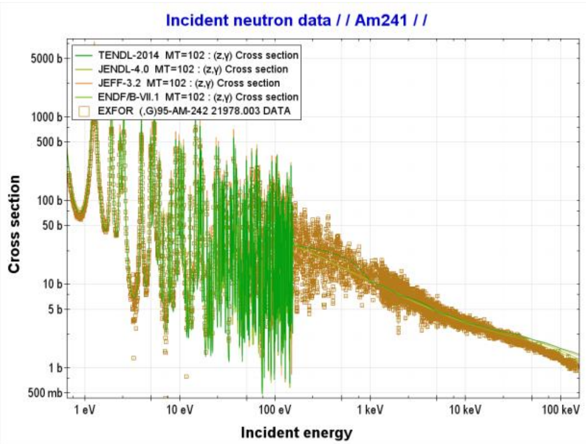


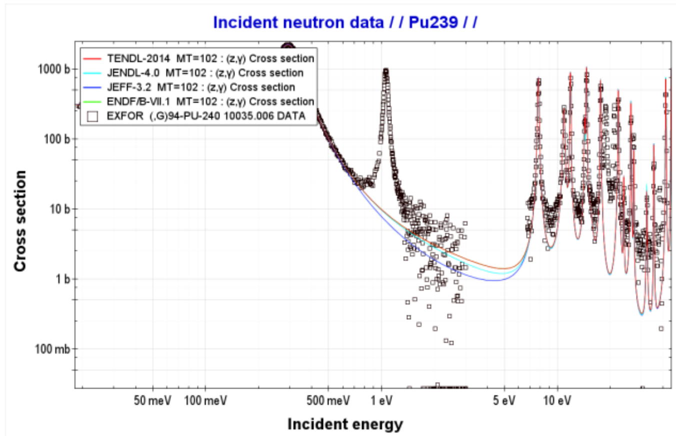
- **SCM´s Methodology (**JEF/DOC-1778, Nov 2016**)**
  - Limitation: **Resonance region**

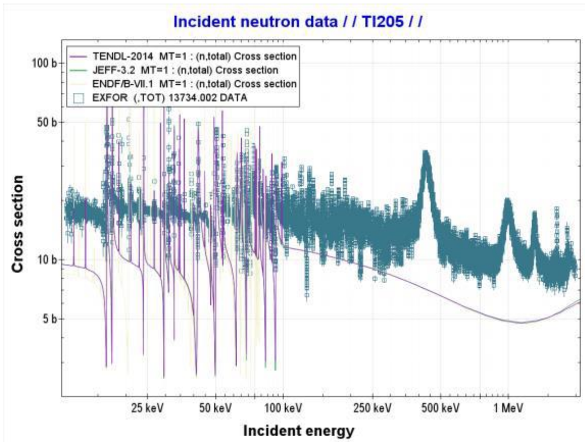




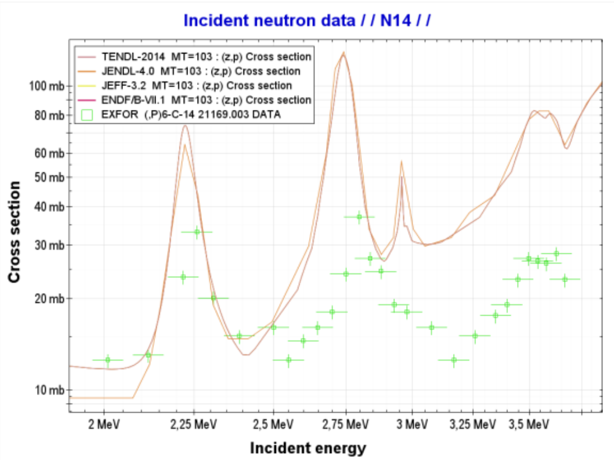
- **SCM´s Methodology (JEF/DOC-1778, Nov 2016)**
  - EXFOR is in resonance but ENDF is in no-resonance region

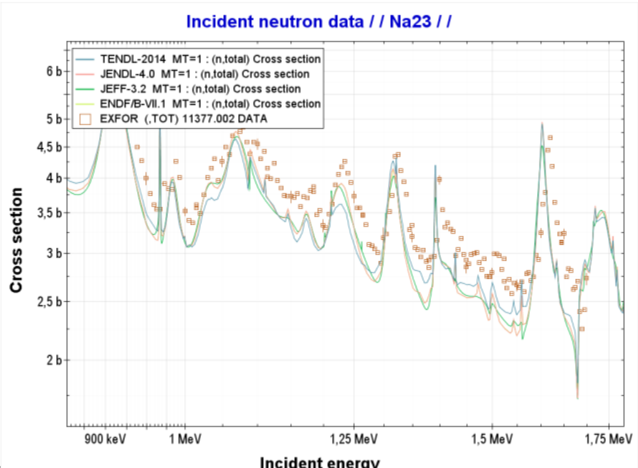


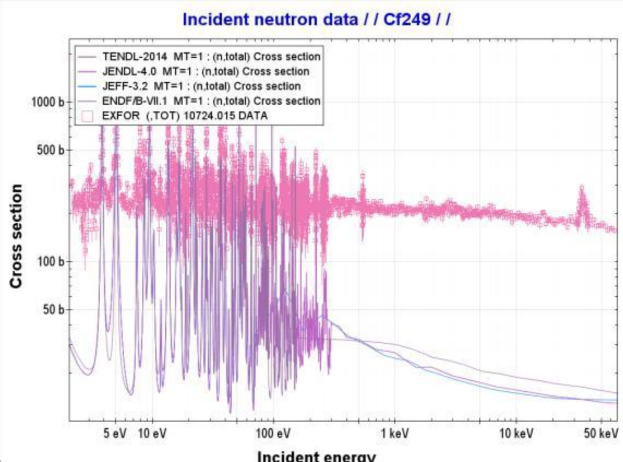




  - EXFOR is shifted from ENDF







2. NEA activities in 2017

- **Motivation:** New evaluations based on TOF measurements

NTOF

ENDF/B-VIIIb4 and JEFF-3.3

1. n-079_Au_197.endf: determined in measurements done at GELINA and n_TOF
2. n-090_Th_232.endf: eV according to the latest results obtained at n_TOF [Gu05]

GELINA

ENDF/B-VIIIb4

1. n-025_Mn_055.endf:Aerts et al. Capture cross sections measured at GELINA in 2006, 2525 1451
2. n-028_Ni_058.endf:et al.(2) and the GELINA very high resolution transmission 2825 1451
3. n-028_Ni_060.endf:et al.(2) and the GELINA very high resolution transmission 2831 1451
4. n-029_Cu_063.endf:Guber et al.[ref3] | 100 - 90 000 | GELINA | Capt. 58m 2925 1451
5. n-029_Cu_065.endf:Guber et al.[ref3] | 100 - 90 000 | GELINA | Capt. 58m 2931 1451
6. n-048_Cd_106.endf:natural-Cd transmission and capture data measured at GELINA. The 4825 1451
7. n-048_Cd_108.endf:natural-Cd transmission and capture data measured at GELINA. The 4831 1451
8. n-048_Cd_110.endf:natural-Cd transmission and capture data measured at GELINA. The 4837 1451
9. n-048_Cd_111.endf:natural-Cd transmission and capture data measured at GELINA. The 4840 1451
10. n-048_Cd_112.endf:natural-Cd transmission and capture data measured at GELINA. The 4843 1451
11. n-048_Cd_114.endf:natural-Cd transmission and capture data measured at GELINA. The 4849 1451
12. n-048_Cd_116.endf:natural-Cd transmission and capture data measured at GELINA. The 4855 1451
13. n-074_W_182.endf:at the Geel Linear Accelerator (GELINA), Belgium[ref3]. Neutron 7431 1451
14. n-074_W_183.endf:at the Geel Linear Accelerator (GELINA), Belgium[ref3]. Neutron 7434 1451
15. n-074_W_184.endf:at the Geel Linear Accelerator (GELINA), Belgium[ref3]. Neutron 7437 1451
16. n-074_W_186.endf:at the Geel Linear Accelerator (GELINA), Belgium[ref3]. Neutron 7443 1451
17. n-079_Au_197.endf: determined in measurements done at GELINA and n_TOF. 7925 1451
18. n-090_Th_232.endf:Schillebeeckx(2) capture data(GELINA), and Gunsing(3) capture 9040 1451
19. n-092_U_238.endf:** GELINA capture and ORNL transmission data. **9237 1451
20. n-094_Pu_240.endf:than those used in the GELINA transmission measurements (Kolar et 9440 1451

JEFF-3.3T3

1. 25-Mn-55g.jeff33t3:Aerts et al. Capture cross sections measured at GELINA in 2006, 2525 1451 443
2. 29-Cu-63g.jeff33t3:Guber et al.[ref3] | 100 - 90 000 | GELINA | Capt. 58m 2925 1451 34
3. 29-Cu-65g.jeff33t3:Guber et al.[ref3] | 100 - 90 000 | GELINA | Capt. 58m 2931 1451 34
4. 45-Rh-103g.jeff33t3: E < 600 eV New parameters from the analysis of recent GELINA 4525 1451 146
5. 48-Cd-106g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4825 1451 45
6. 48-Cd-108g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4831 1451 45
7. 48-Cd-110g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4837 1451 40
8. 48-Cd-111g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4840 1451 40
9. 48-Cd-112g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4843 1451 45
10. 48-Cd-113g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4846 1451 45
11. 48-Cd-114g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4849 1451 45
12. 48-Cd-116g.jeff33t3: of Neutron Resonance Cross Section Data at GELINA", NDS 119 4855 1451 64
13. 53-I-127g.jeff33t3: THE GELINA FACILITY [Nog04]. RESONANCE SHAPE ANALYSIS WERE 5325 1451 103
14. 53-I-129g.jeff33t3: THE GELINA FACILITY [Nog04]. RESONANCE SHAPE ANALYSIS WERE 5331 1451 103
15. 72-Hf-174g.jeff33t3: using GELINA at IRMM GEEL (Ref.6.). A further natural 7225 1451 82
16. 72-Hf-176g.jeff33t3: using GELINA at IRMM GEEL (Ref.6.). A further natural 7231 1451 82
17. 72-Hf-177g.jeff33t3: using GELINA at IRMM GEEL (Ref.6.). A further natural 7234 1451 82
18. 72-Hf-178g.jeff33t3: using GELINA at IRMM GEEL (Ref.6.). A further natural 7237 1451 82
19. 72-Hf-179g.jeff33t3: using GELINA at IRMM GEEL (Ref.6.). A further natural 7240 1451 82
20. 72-Hf-180g.jeff33t3: using GELINA at IRMM GEEL (Ref.6.). A further natural 7243 1451 82
21. 74-W-182g.jeff33t3:GELINA [Em12]. These include transmission and capture data on 7431 1451 30
22. 74-W-183g.jeff33t3:GELINA [Em12]. These include transmission and capture data on 7434 1451 34
23. 74-W-184g.jeff33t3:GELINA [Em12]. These include transmission and capture data on 7437 1451 30
24. 74-W-186g.jeff33t3:GELINA [Em12]. These include transmission and capture data on 7443 1451 30
25. 79-Au-197g.jeff33t3: determined in measurements done at GELINA and n_TOF. 7925 1451 52
26. 90-Th-232g.jeff33t3:Schillebeeckx(2) capture data(GELINA), and Gunsing(3) capture 9040 1451 444
27. 92-U-238g.jeff33t3:** GELINA capture and ORNL transmission data. **9237 1451 22

2. NEA activities in 2017

- **New SCM´s Methodology applied in RRR**

1) Applied to large ENTRIES (e.g TOF measurements)
2) **Average ratio (EXFOR/ENDF) in different bins of energy:** "Checking Normalization"
3) **Convolution of EXFOR and Evaluation data**: "Looking for a resolution function"

   - EXFOR: E, δE,<y(x)>, δy
   - Evaluations $P(p_1,p_2,\ldots p_N)$ based on Model (e.g. R-Matrix)

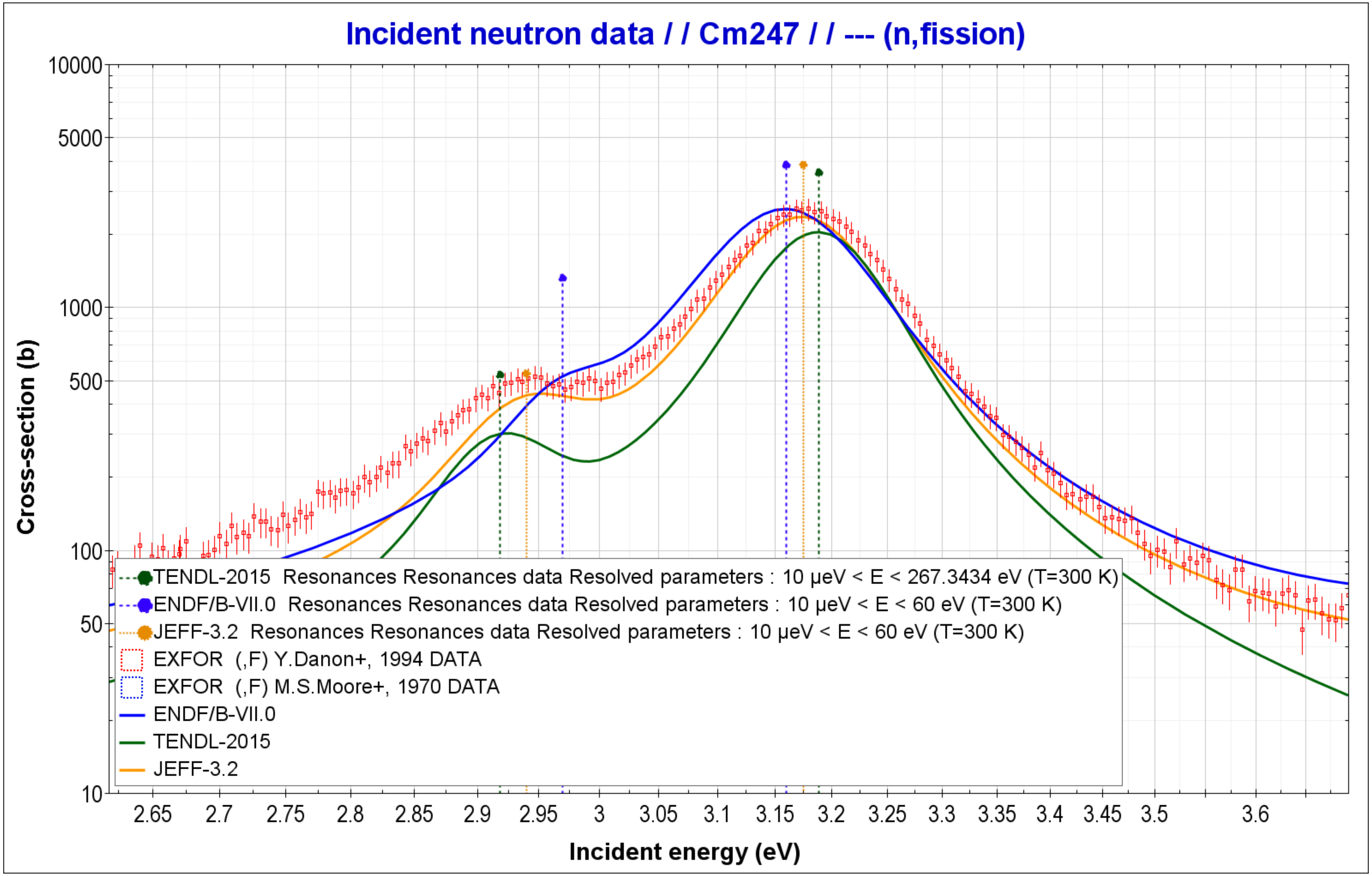
   where: $\langle y(E)\rangle^{EXFOR} = \int f^{res}(E',E) \times f^{model}(E')dE'$

   - Finding the right "f^{res}" discretized in **energy bins/intervals**
   - **Assuming a Gaussian** "f^{res}"

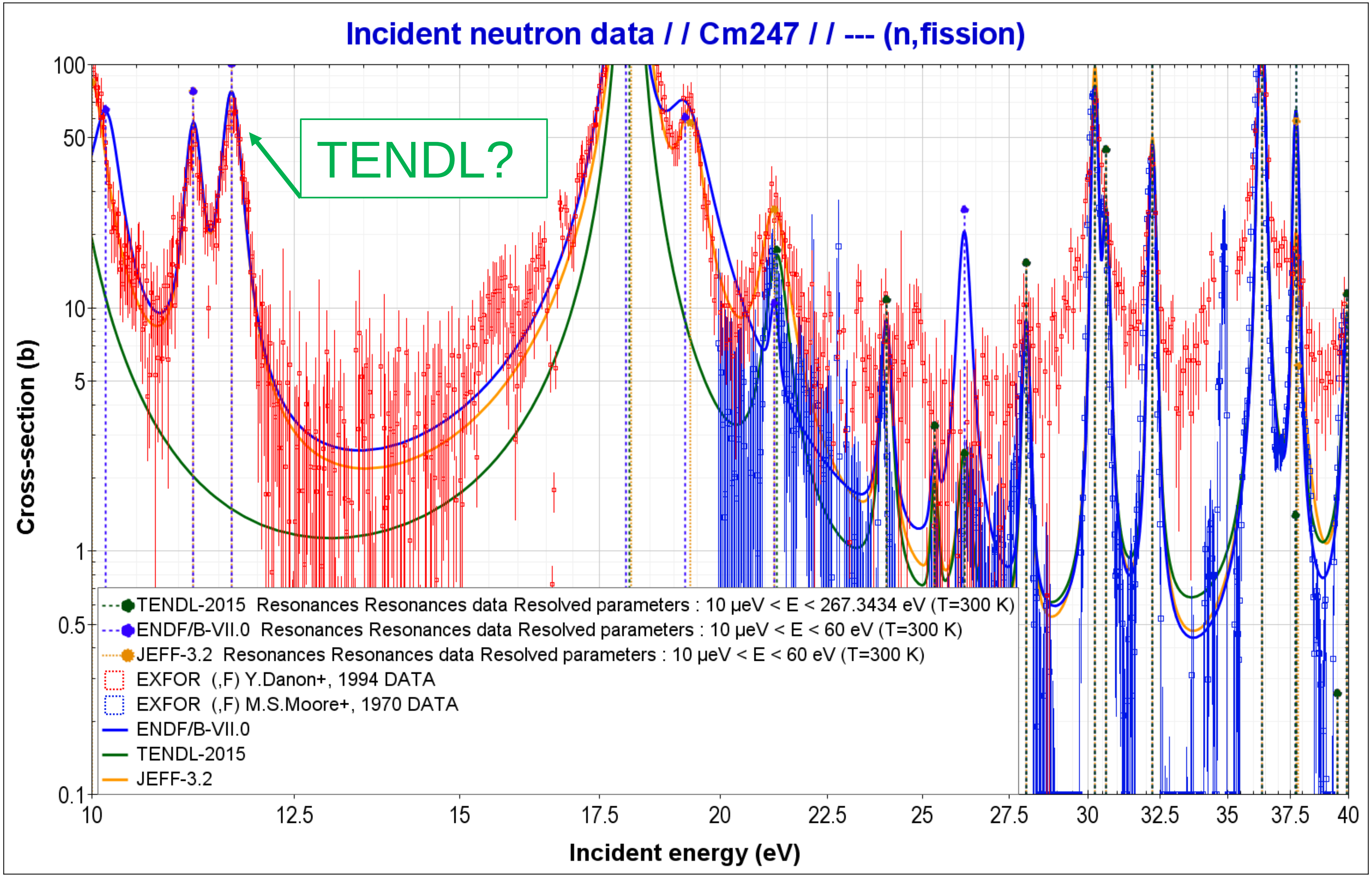
$$f^{res}(E',E) = \frac{1}{\Delta}\exp(-\frac{(E'-Er)^2}{2\Delta^2})$$

     - Identifying the P values in evaluated files (e.g lack of Er ?)
     - $f^{model}(E)$ at the room temperature (Doppler broadening)
     - Normalization: shift at the maximum: $\max(f^{model}(E))$ to Y^{max}
     - Δ^{res} versus nominal resonance energy by intervals

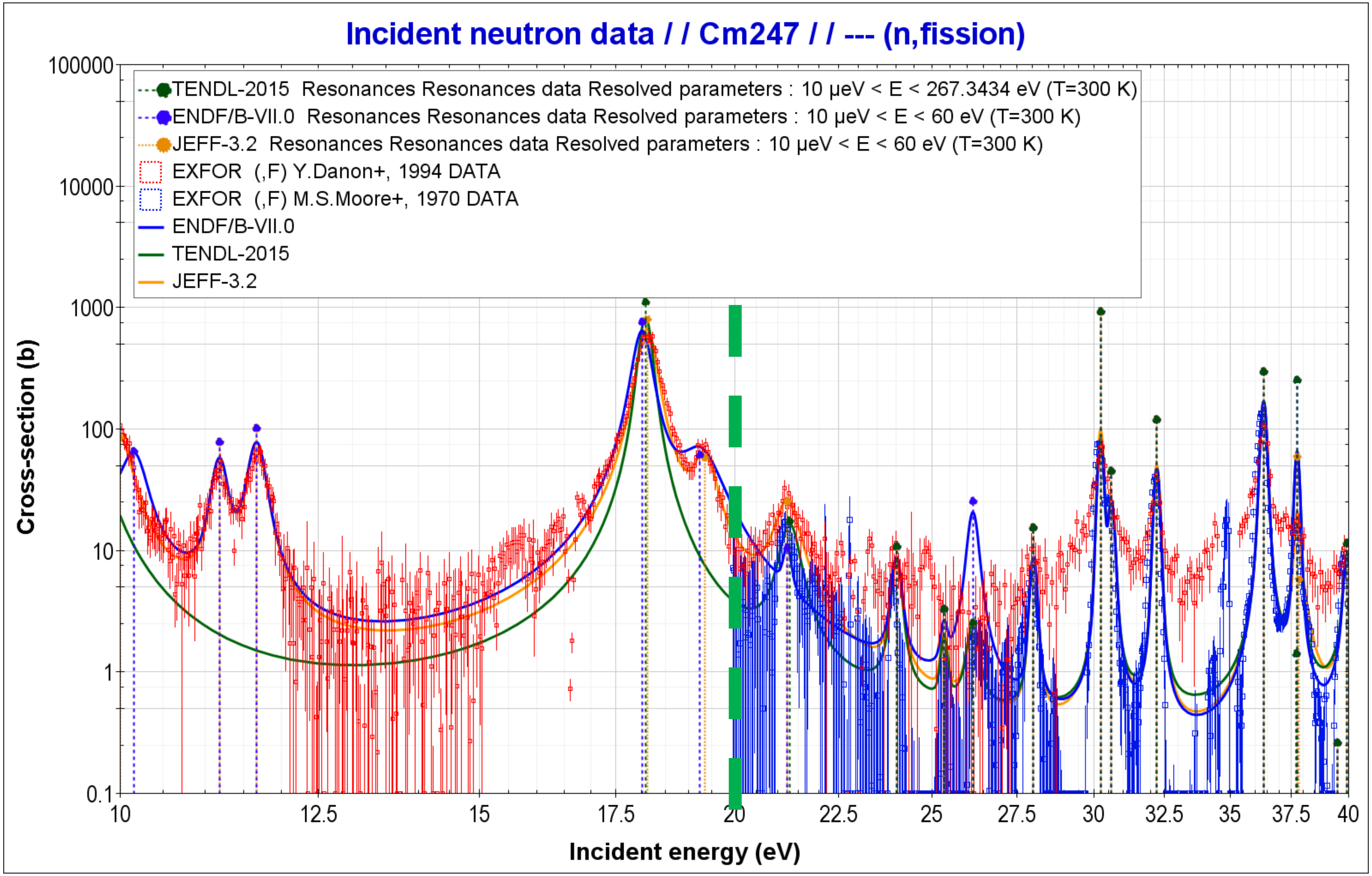
❑ Different Er values ? Shift to the EXFOR value



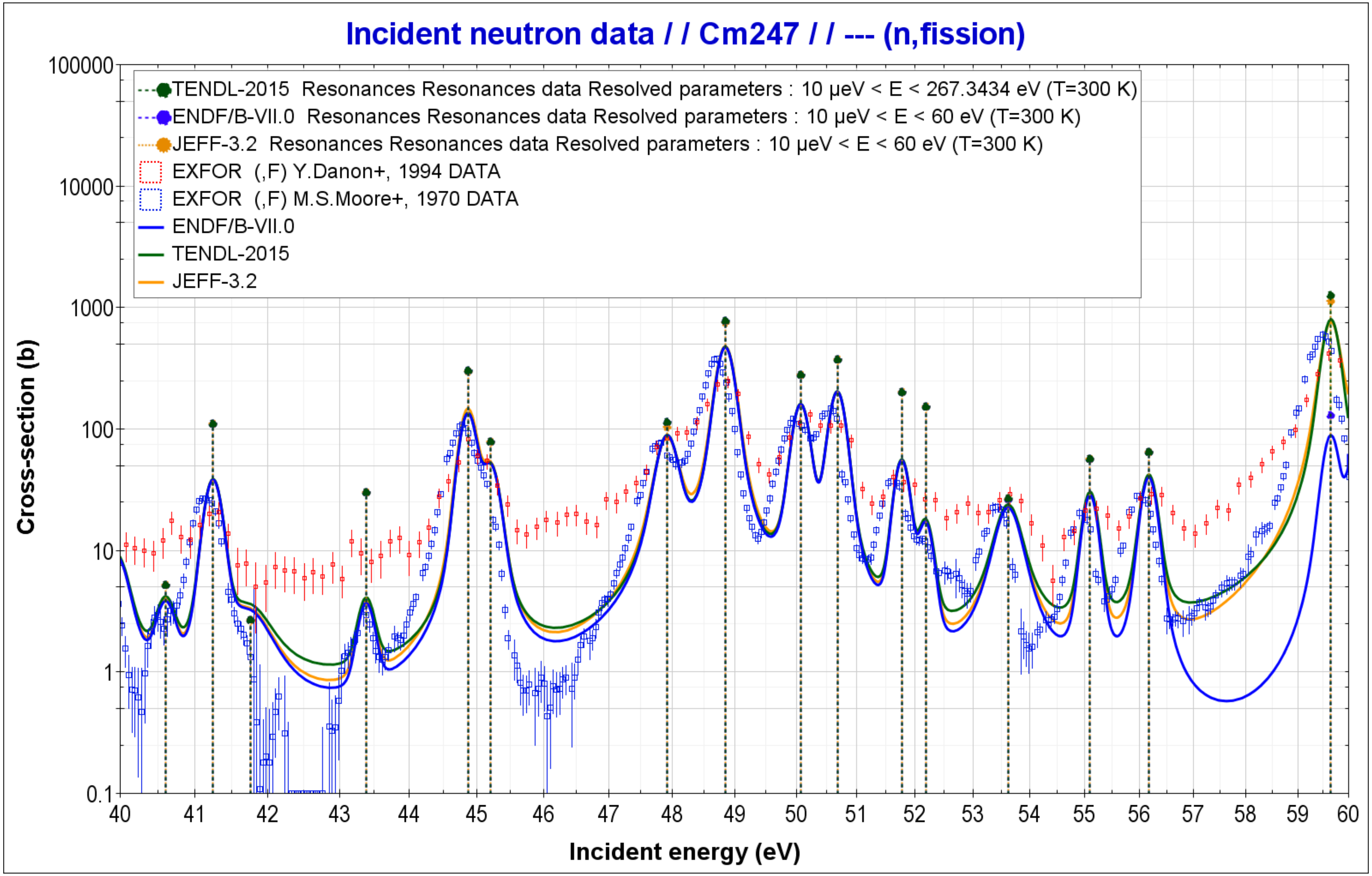
❑ Lack of Er in the evaluation ?



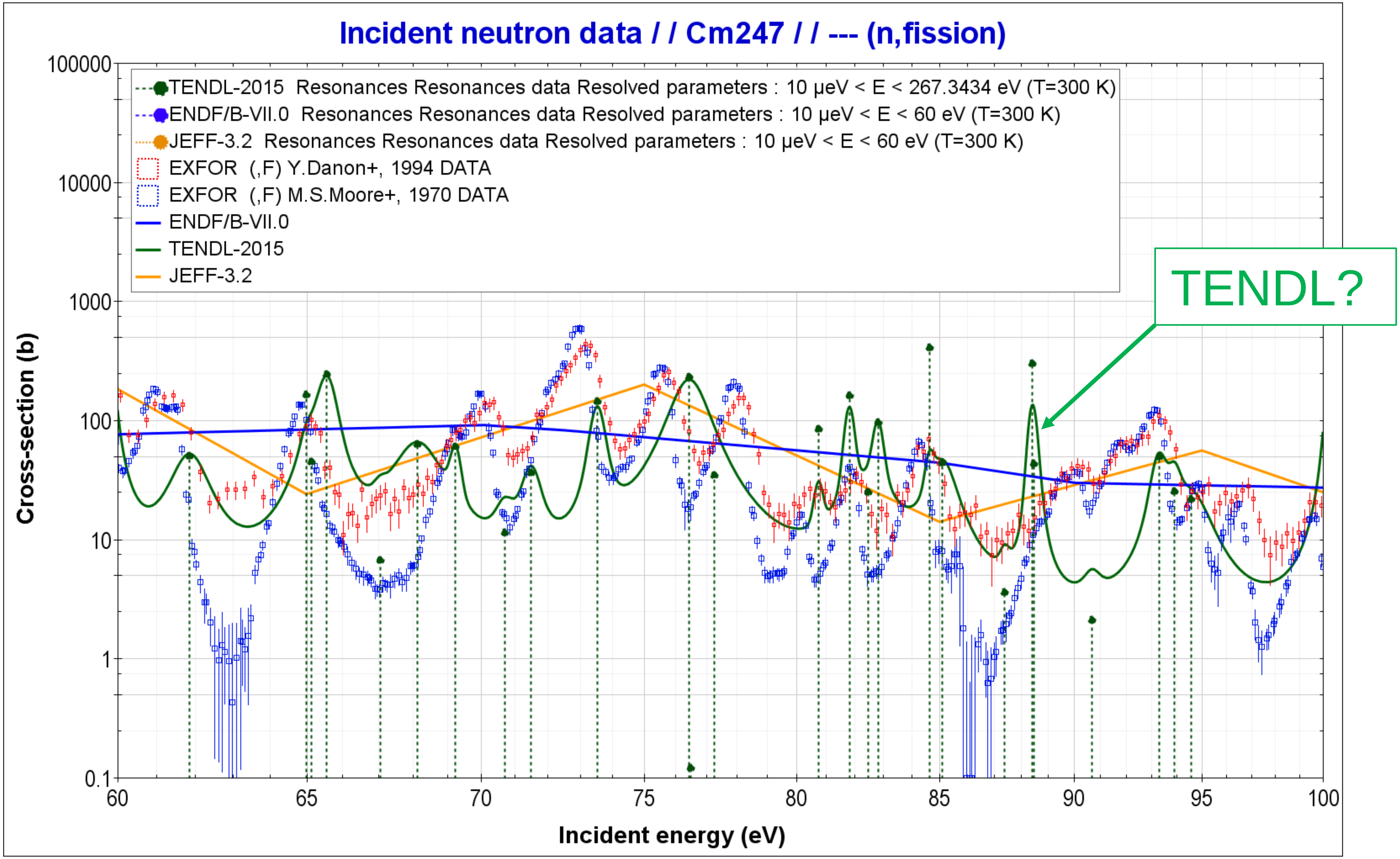
❑ Resolution change as a function of E?



❑ How do we to take into account Exfor uncertainties?



❑ Any possibility to extend the RRR ?



2. NEA activities in 2017

❑ Conclusion

- **Problem with the current SCM Methodology** based on "distances": Large fluctuations in the RRR provoke difficulties to analyze this info

- **What type of data do we want to check?** Data in RRR/URR, e.g. TOF measurements, …

- **How do we test these data ?** Ratio avg. EXFOR/ENDF, resolution functions… in energy bins, per resonance energy, …

- **What type of data do we expect from the new method?** Identify potential outliers, lack of resonances in the evaluation, resolution function of EXFOR data per energy bin, …

- **The benefit of this work:** EXFOR and Evaluators

Acknowledgments

To acknowledge Gottfried Berton (SCM) for his high motivation to participate in this work, and Luiz Leal (IRSN) for the stimulating and fruitful discussions.