EVALUATION OF NEUTRON INDUCED REACTIONS ON ^{238}U NUCLEUS

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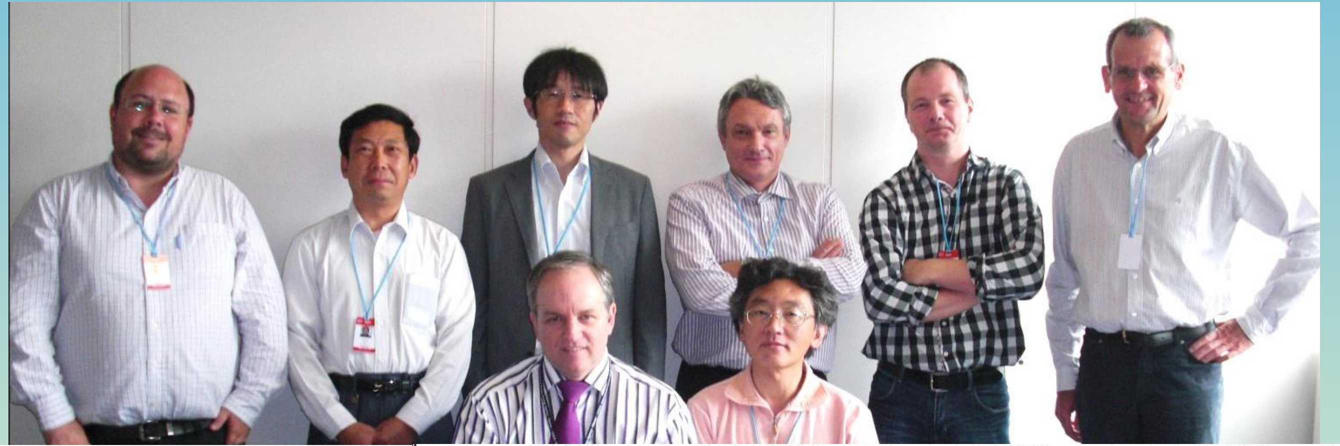
Adam Daskalakis and Yaron Danon, Rensselaer Polytechnic Institute, USA
Gilles Noguere and David Bernard, CEA Cadarache, France

+WPEC SG26

IAEA TM 2011



IAEA
International Atomic Energy Agency

INDC(NDS)-0597
Distr. J+NM

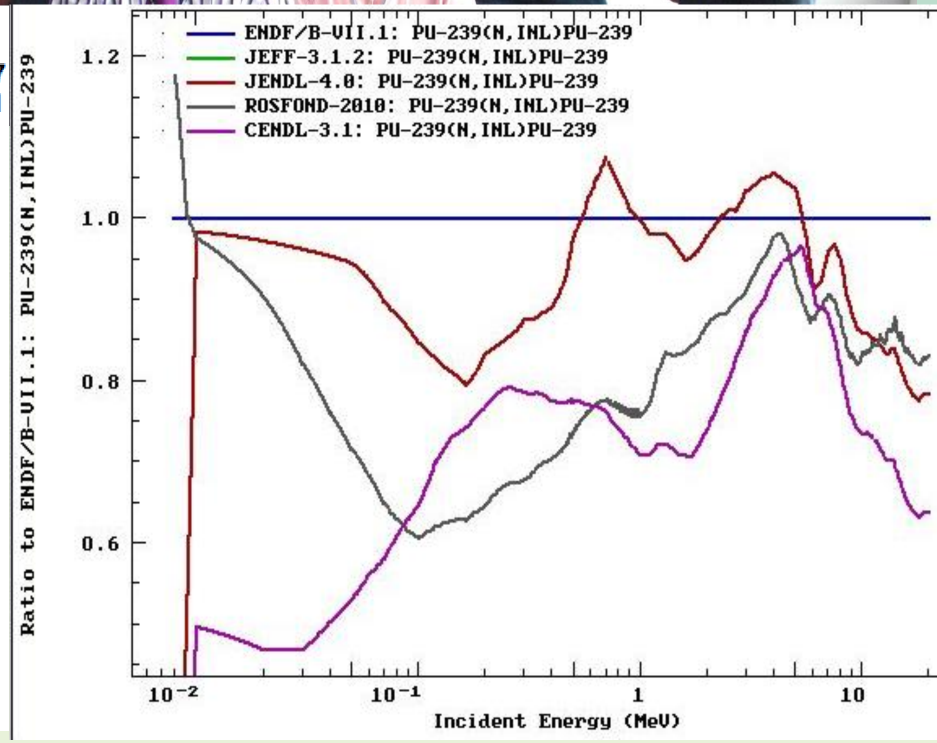
INDC International Nuclear Data Committee

Summary Report

Technical Meeting on

Inelastic Scattering and Capture Cross-section Data of Major Actinides in the Fast Neutron Region

IAEA Headquarters
Vienna, Austria
6 – 9 September 2011



A.J. Plompen, T. Kawano and RC, Technical report INDC(NDS)-0597 (IAEA,Vienna,2012)
http://www-nds.iaea.org/publications/indc/indc-nds-0597.pdf

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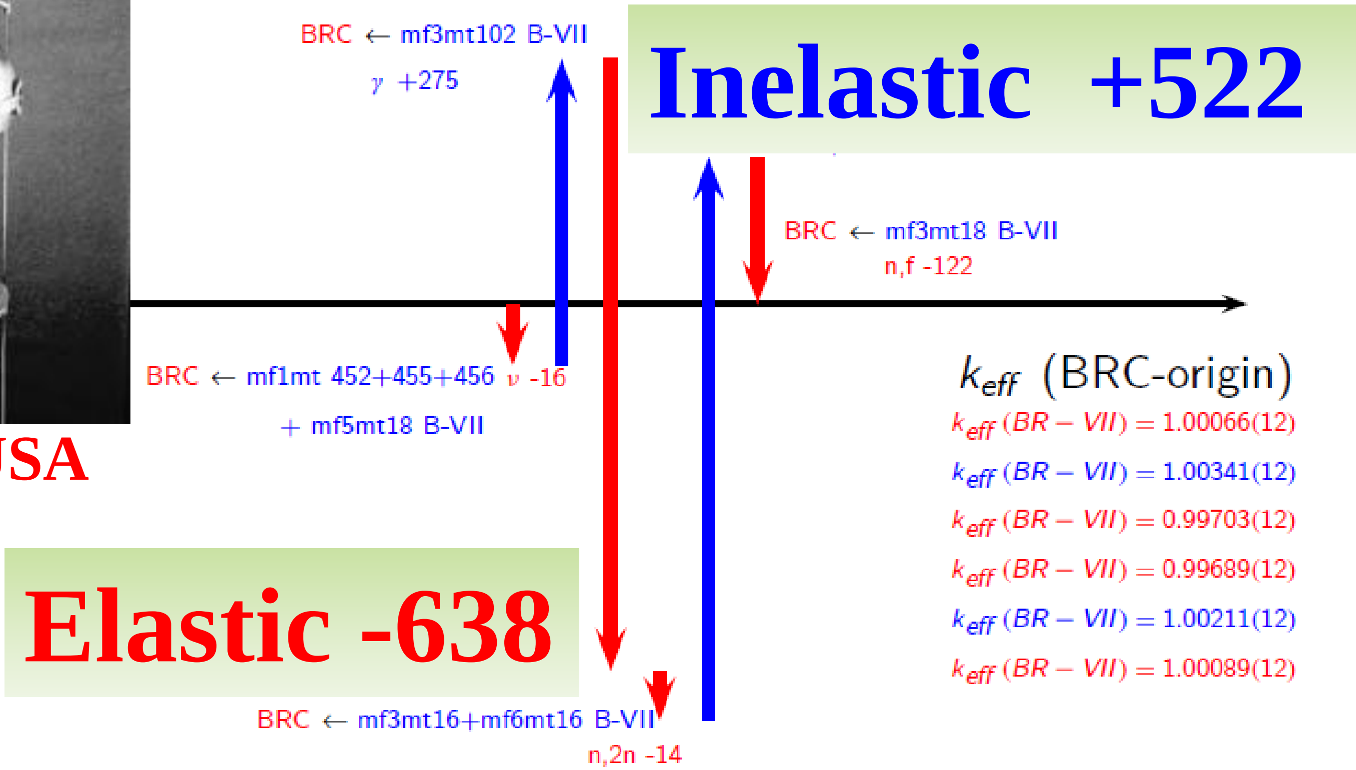
Large compensations effects noted !

But as known from B. Morillon study (calculations MCNP5)

JEZEBEL $k_{eff}(BRC) = 1.00082(11)$ $k_{eff}(B\text{-}VII) = 1.00060(12)$

LANL, USA



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IAEA TM recommendations $^{238}U(n,inl)$

7. For the low energy range (<3 MeV) the compound decay introduces additional degrees of freedom (level densities, strength functions, fission, width fluctuations). For better understanding the compound nuclear reaction mechanism on actinides a simple system must be studied. Predictions for neutron induced reactions on ^{238}U below 1 MeV should be compared.

$^{238}U(n,f)$ and $^{238}U(n,\gamma)$ – fitted in STD

$^{238}U(n,\gamma)$ SPA in ^{252}Cf: 67.5 ± 0.7 mb (1.0%)

$^{238}U(n,f)$ SPA in ^{252}Cf: 318.5 ± 2.1 mb (0.6%)

⇒ ^{238}U is the ideal test nucleus for elastic/inelastic studies

A.J. Plompen, T. Kawano and RC, Technical report INDC(NDS)-0597 (IAEA,Vienna,2012)

http://www-nds.iaea.org/publications/indc/indc-nds-0597.pdf

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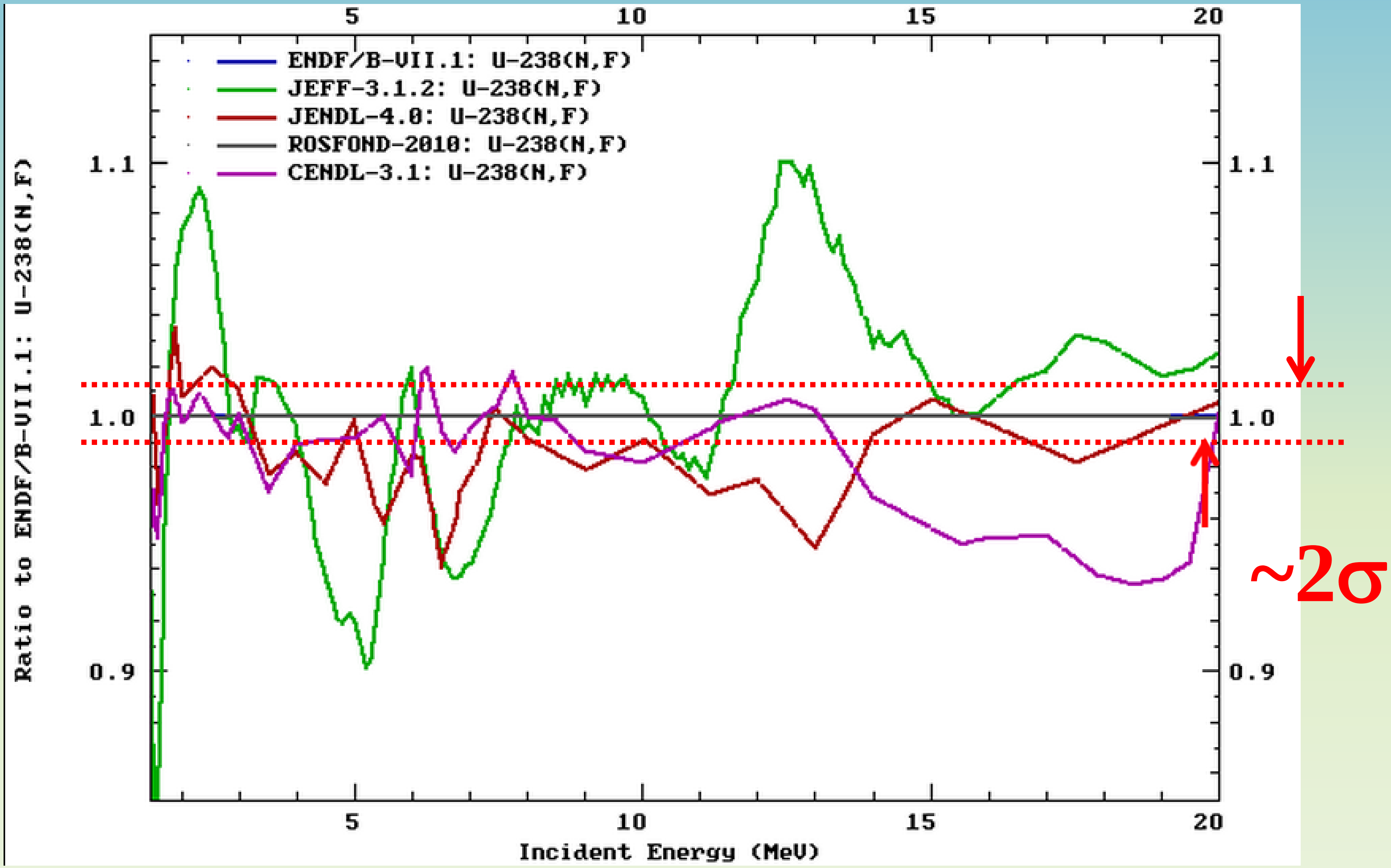
DOES EVAL.FISSION AGREES with STD?



^{238}U(n,f) SPA in ^{252}Cf = 318.5 (0.6%)

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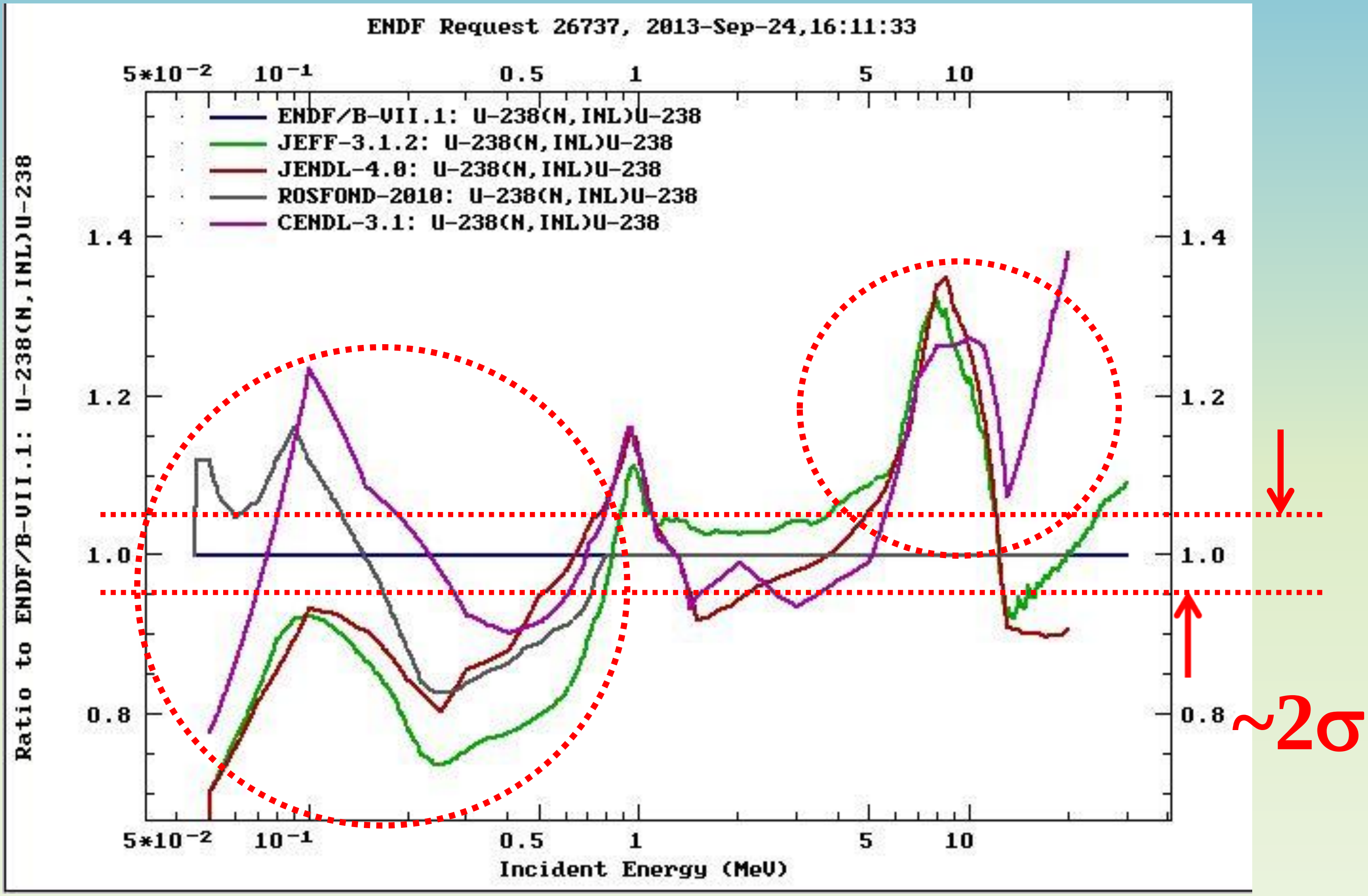
DISCREPANCIES in $^{238}U(n,inl)$



NEMEA7/CIELO workshop, JRC-IRMM
Geel, Belgium, 5-8 November 2013

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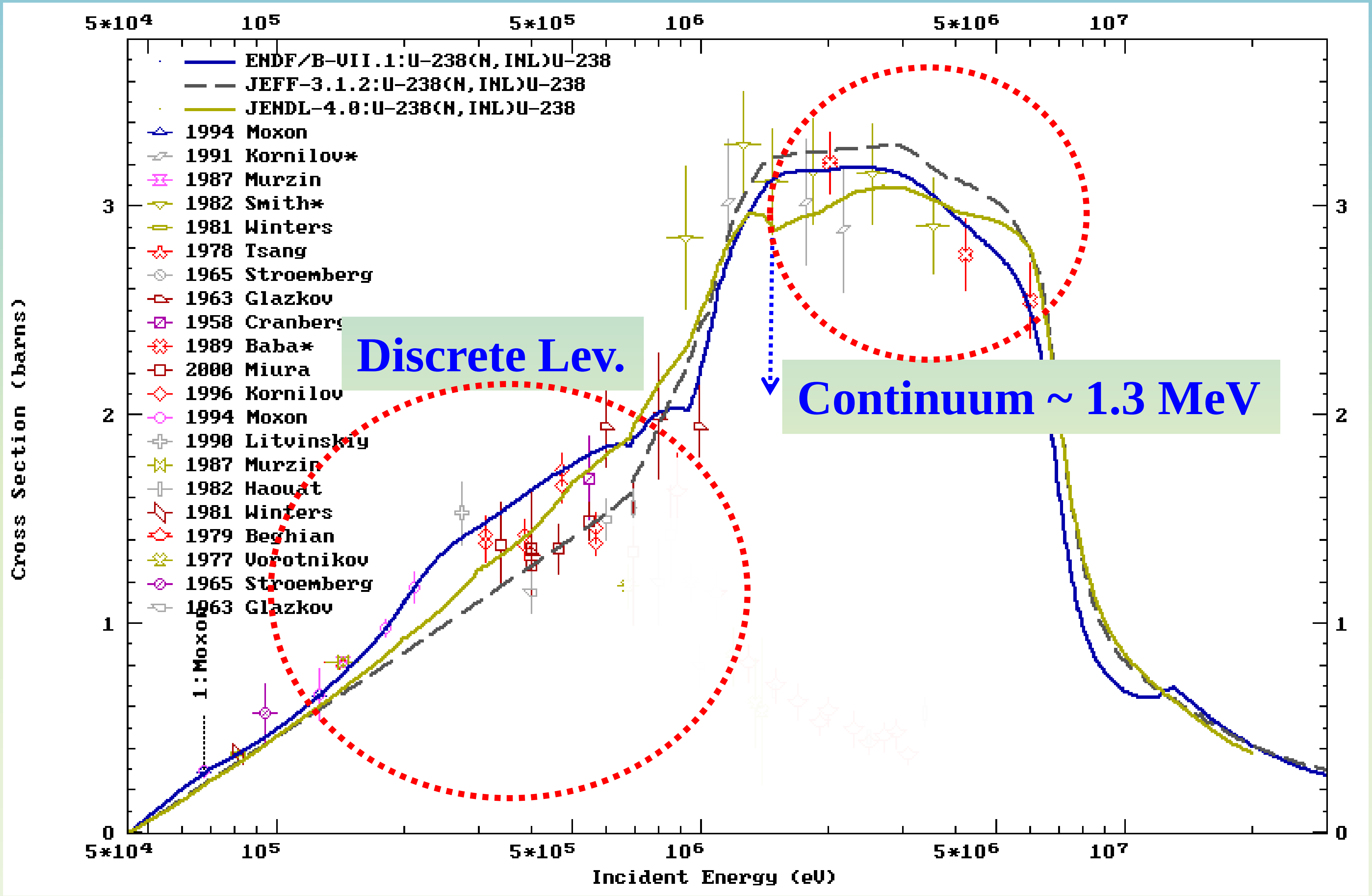
Starting point: ^{238}U(n,inl)



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Nuclear Data Sheets **108** (2007) 2655

EMPIRE: Nuclear Reaction Model Code System for Data Evaluation

M. Herman[1,*], R. Capote[2], B.V. Carlson[3], P. Obložinský[1], M. Sin[4], A. Trkov[5], H. Wienke[6], and V. Zerkin[2]
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+ recent relevant modelling advances

- ***Dispersive Lane consistent coupled-channel OMPs**:**
  neutron inelastic scattering to discrete levels;
- ***CN-DIR interference effects (as predicted by Moldauer);***
- ***neutron inelastic scattering to the continuum;***
- ***improved fission formalism (descriptive capability)***

*J.M. Quesada *et al.*, EPJ Web of Conferences **42** 02005 (2013)
J.M. Quesada *et al.*, ND2013 conference

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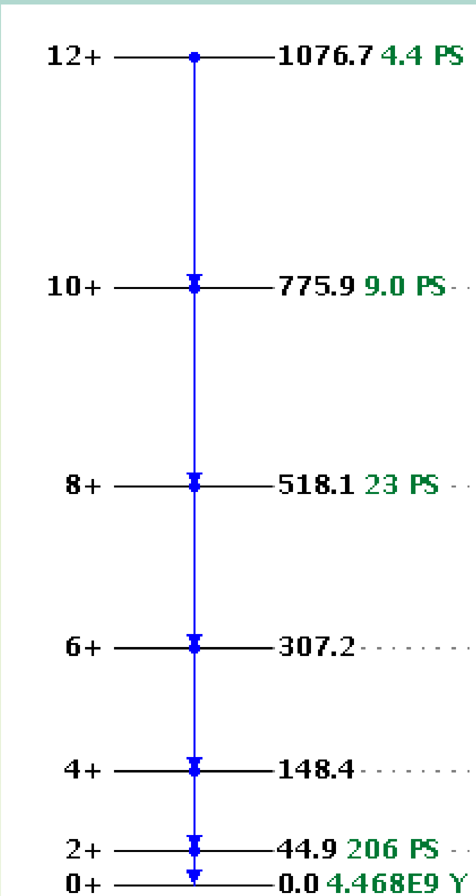
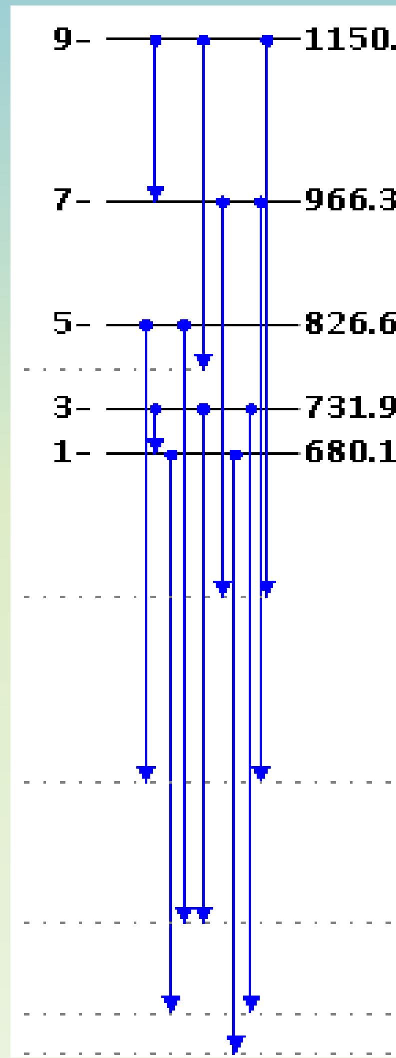
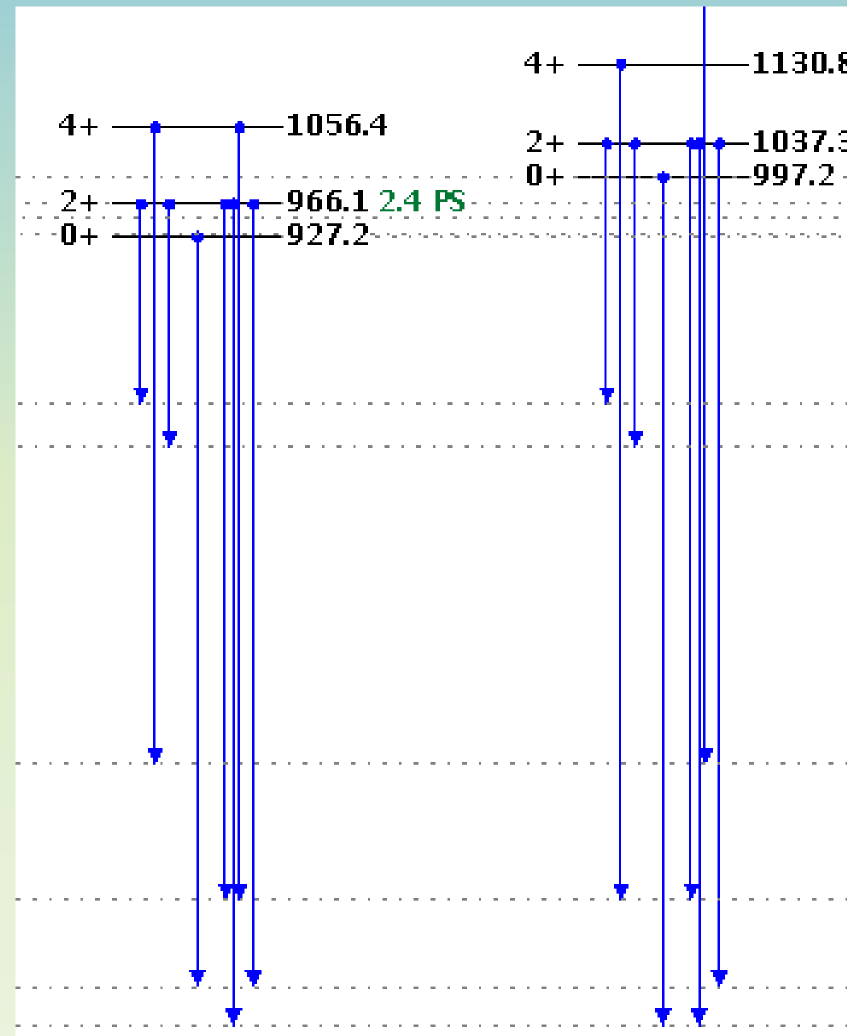
DCCOMP: rigid rotor with soft-rotor corrections

^{238}U







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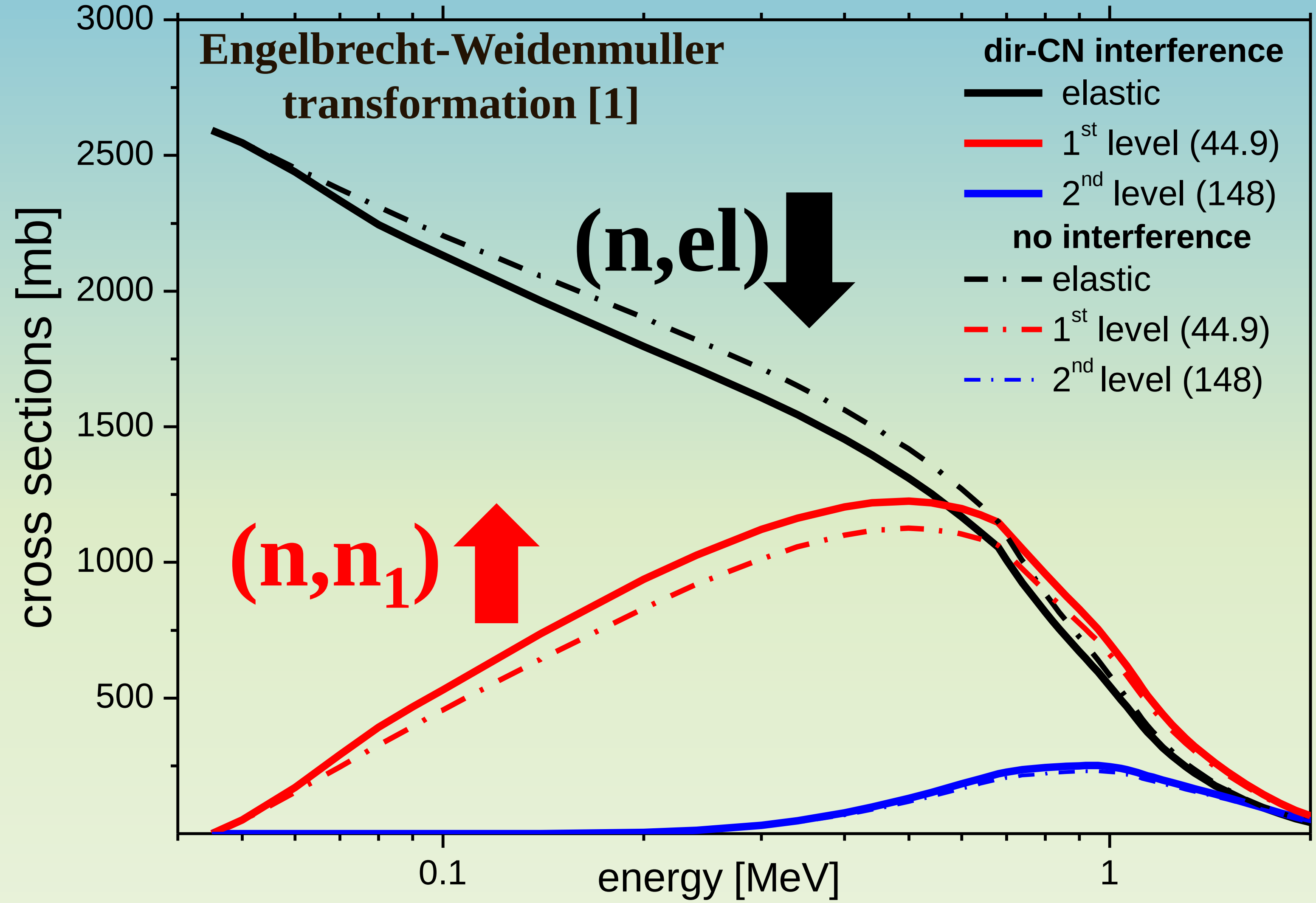
new physics: DIR-CN interference



[1] C.A. Engelbrecht, H.A. Weidenmuller, "Hauser--Feshbach theory and Ericson fluctuations in the presence of direct reactions", Phys.Rev. **C8** (1974) 859-862

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Using differential data

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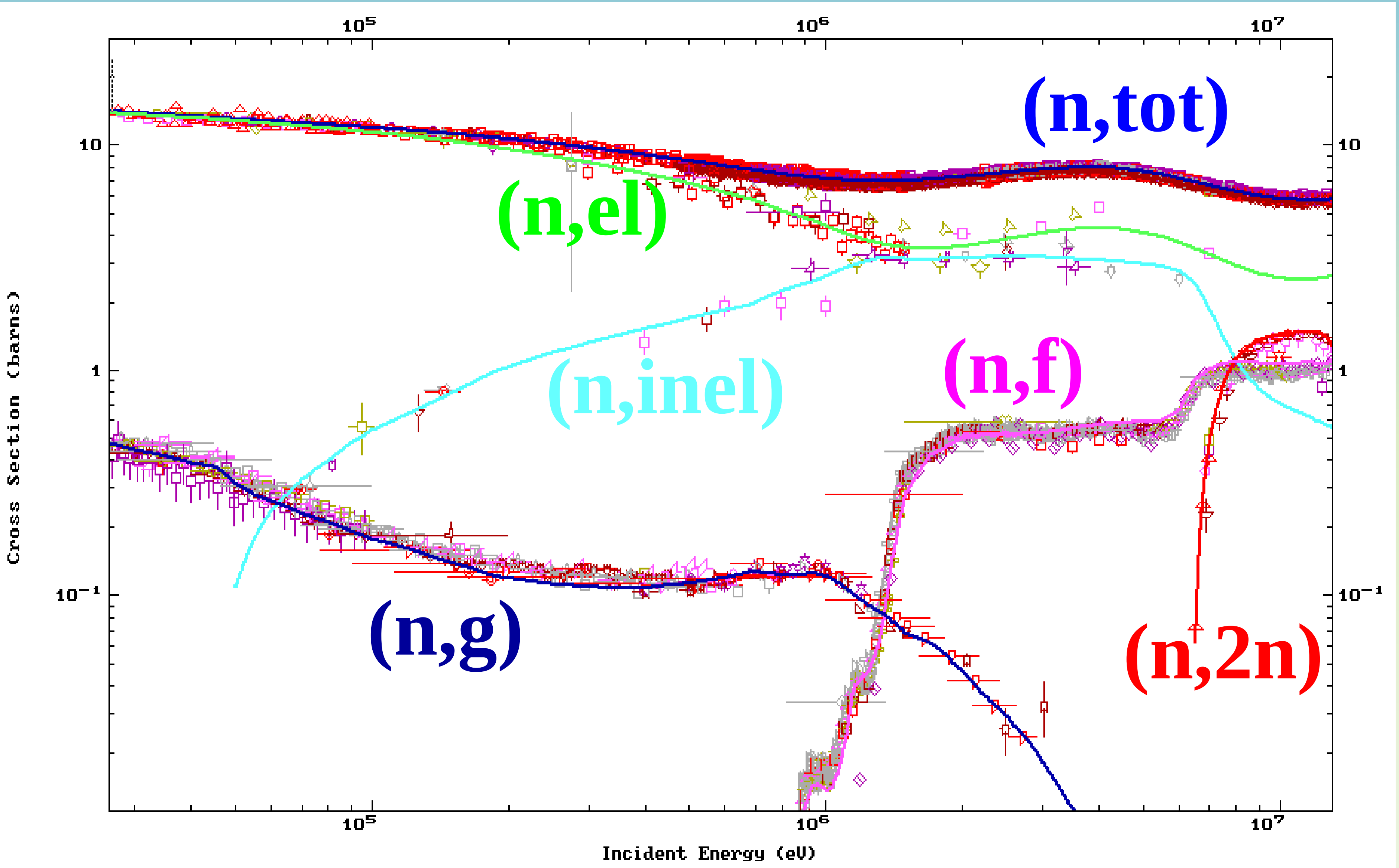
Neutron induced reactions on ^{238}U



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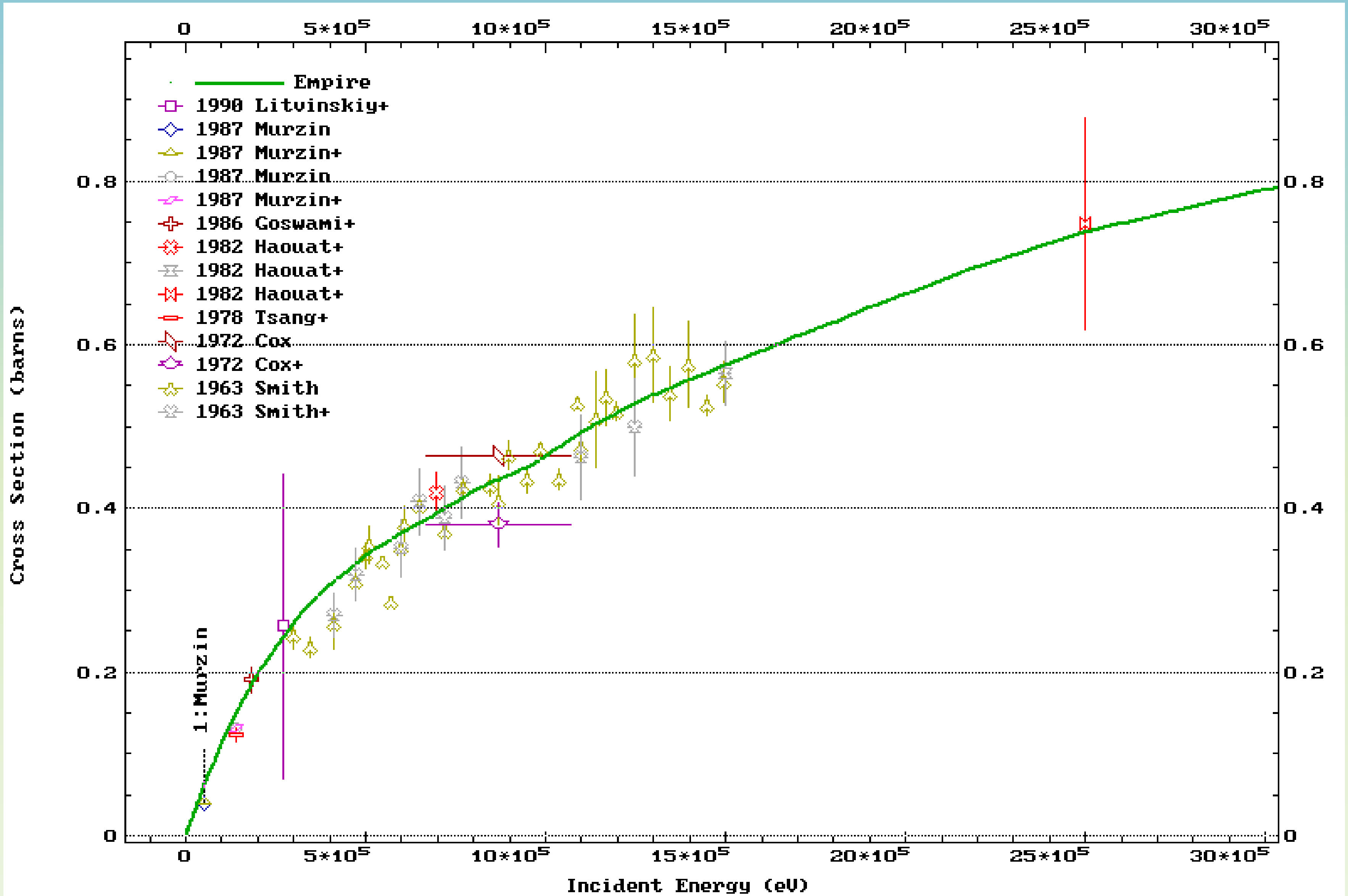
elastic μ-bar (P1 component)



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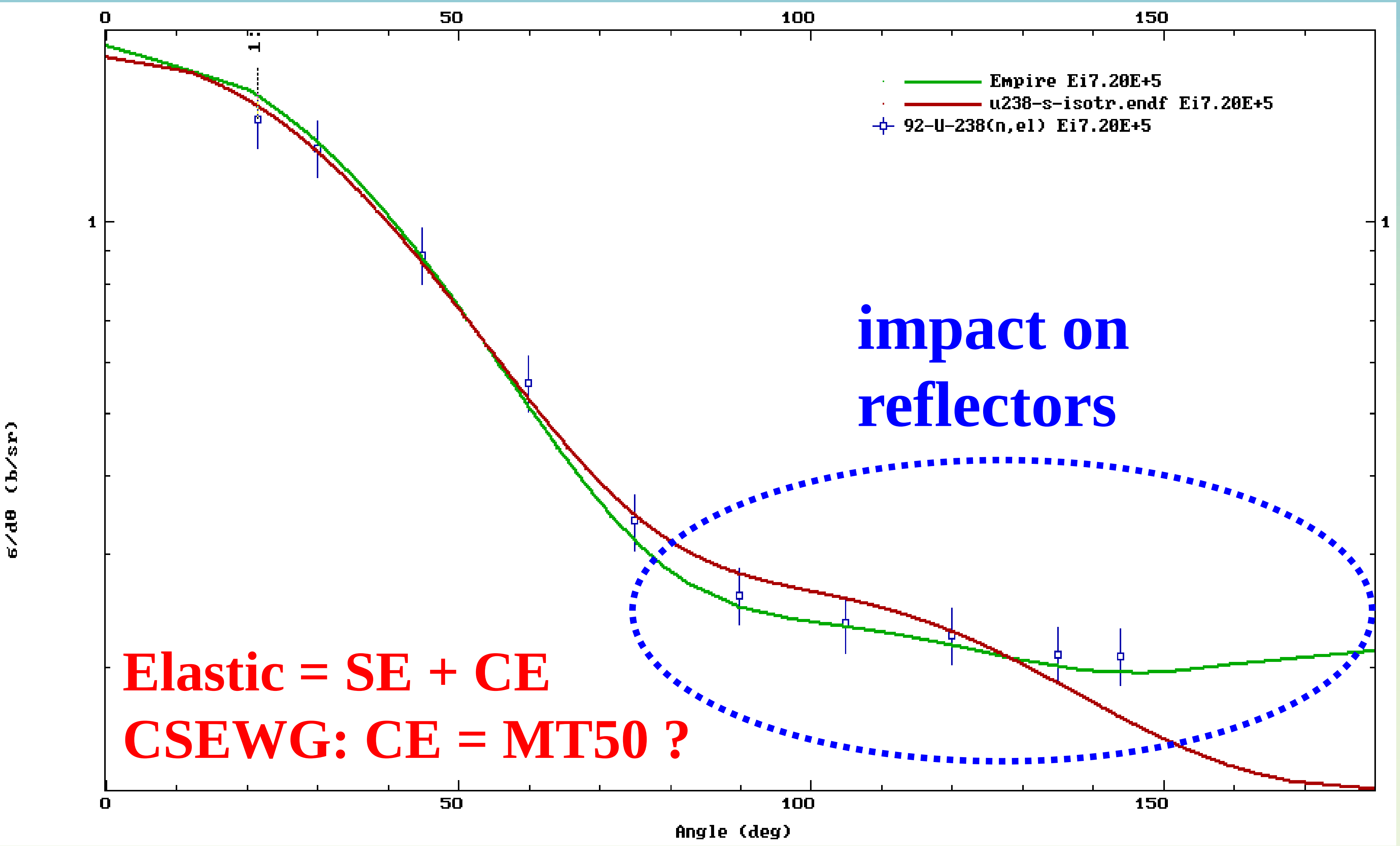
Elastic angular distribution 720 keV



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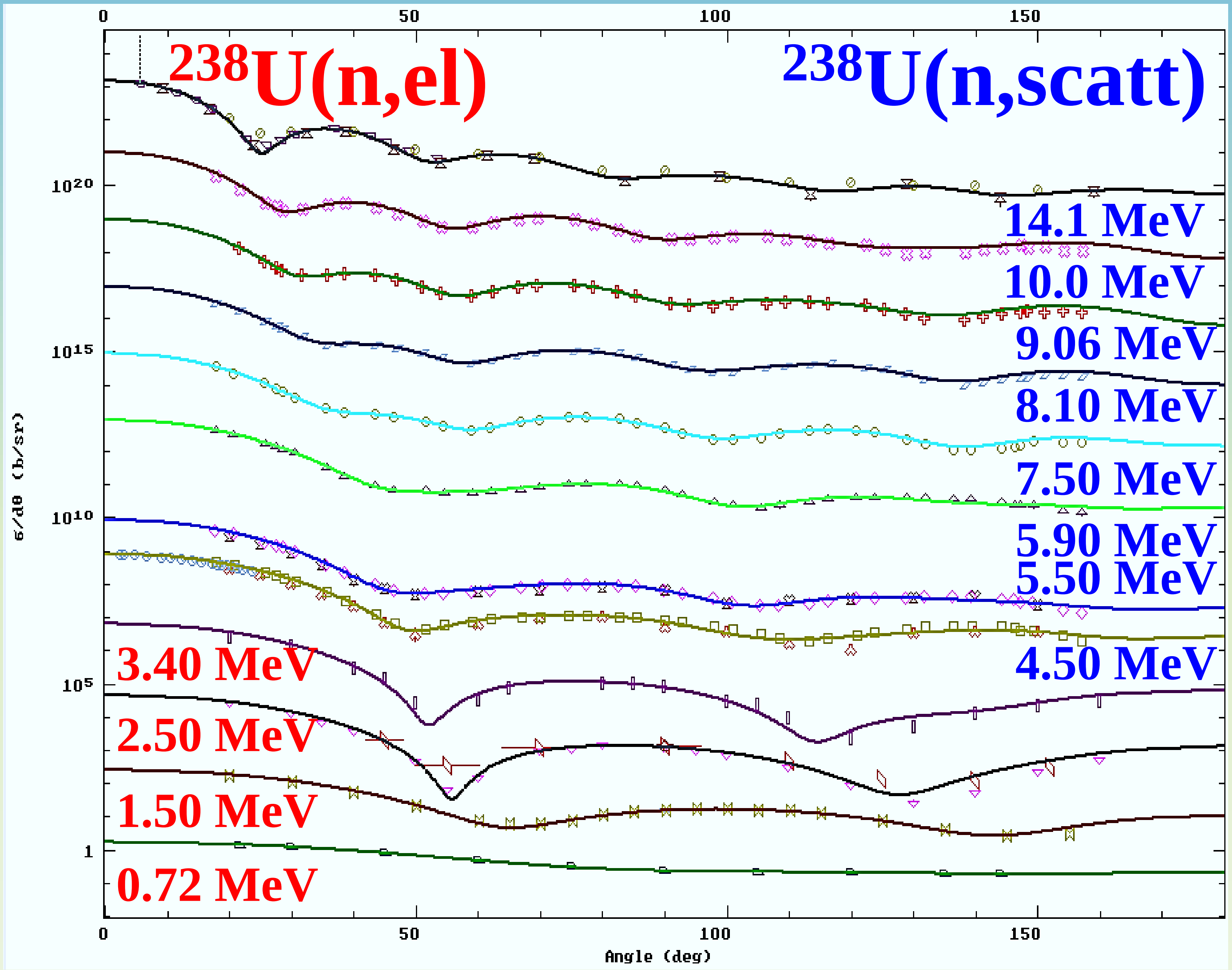

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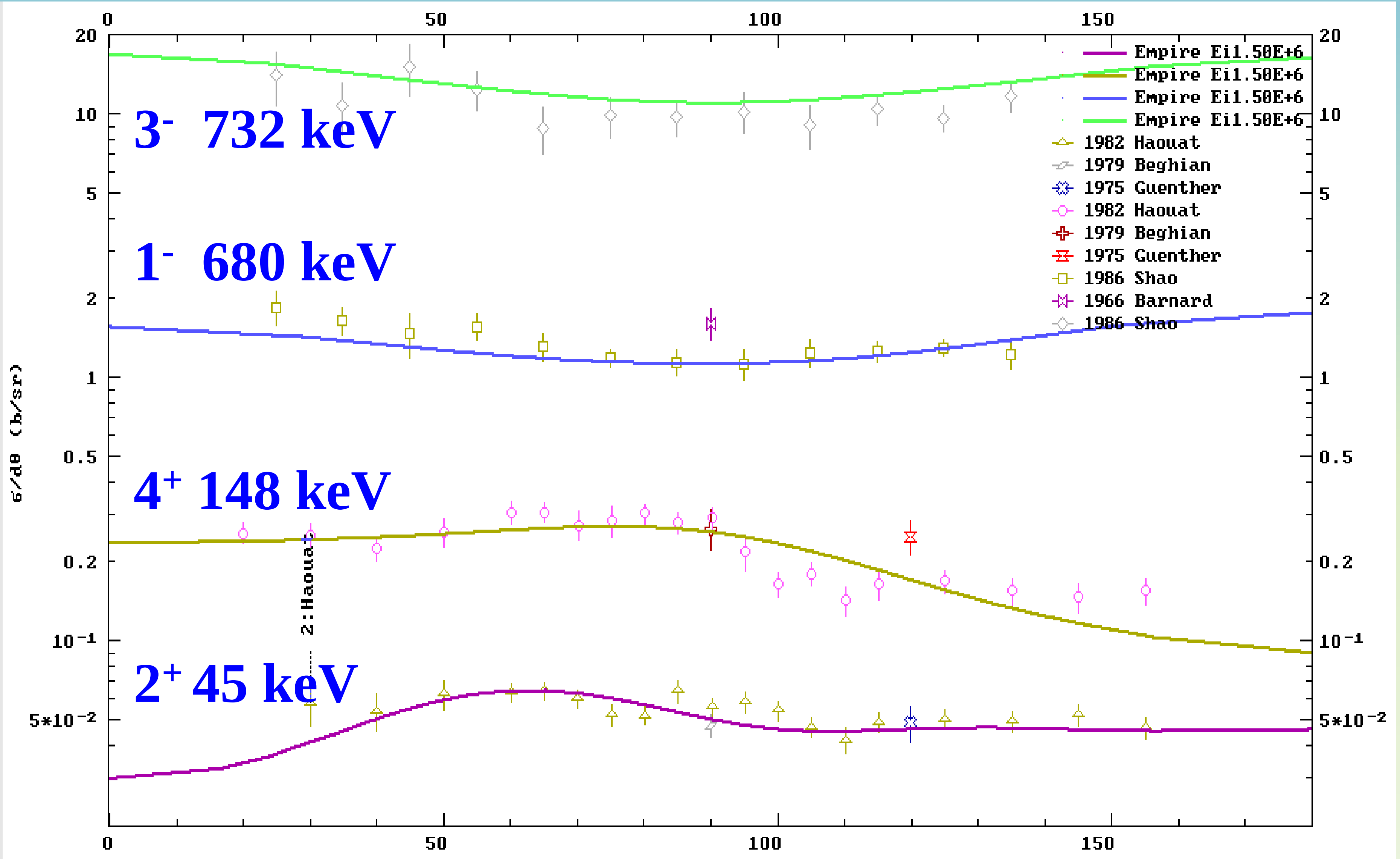
Inelastic angular distributions E_n=1.5 MeV



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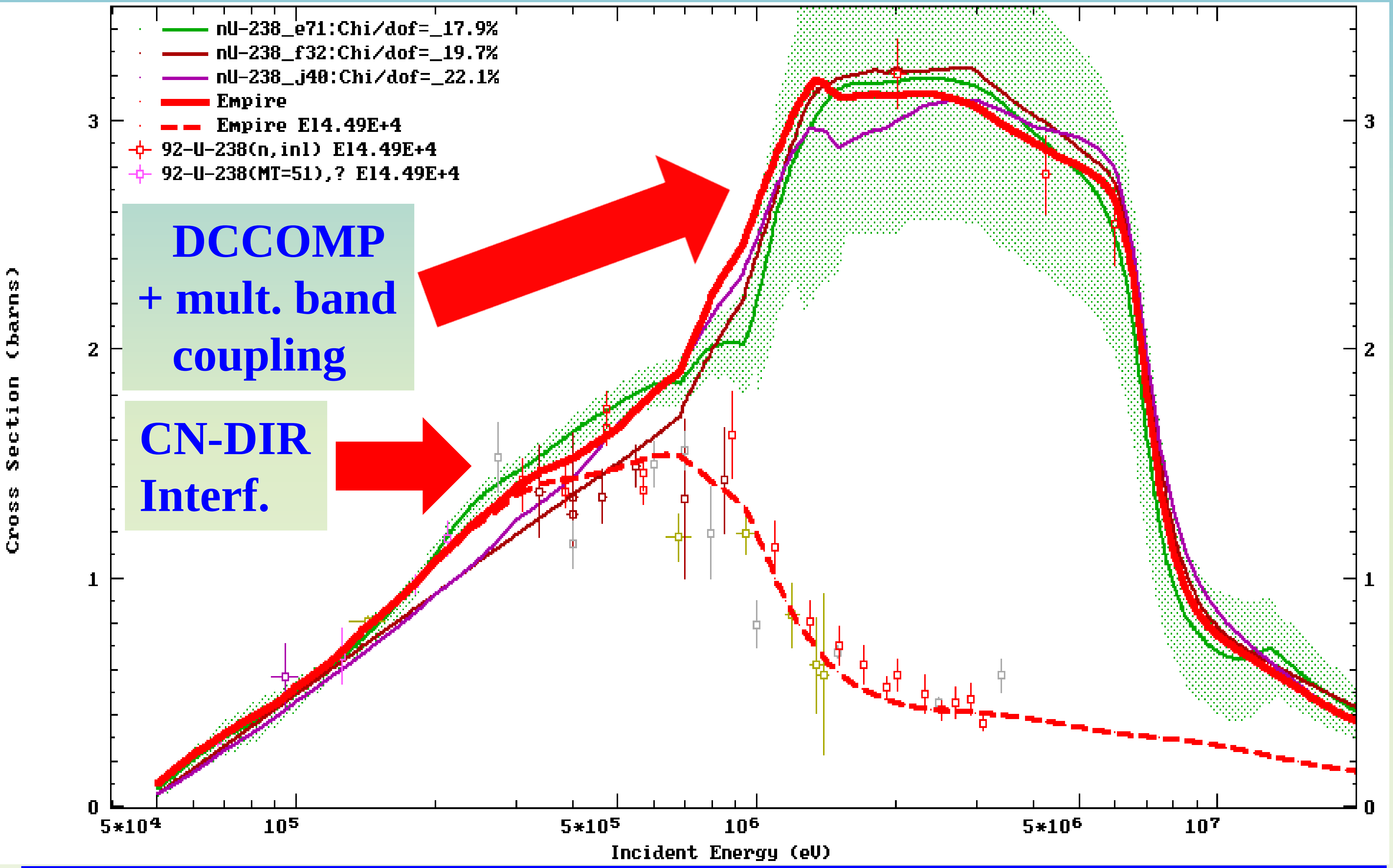
total (and 1st lev) inelastic cross sections



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Using quasi-differential data

(see Y. Danon presentation)

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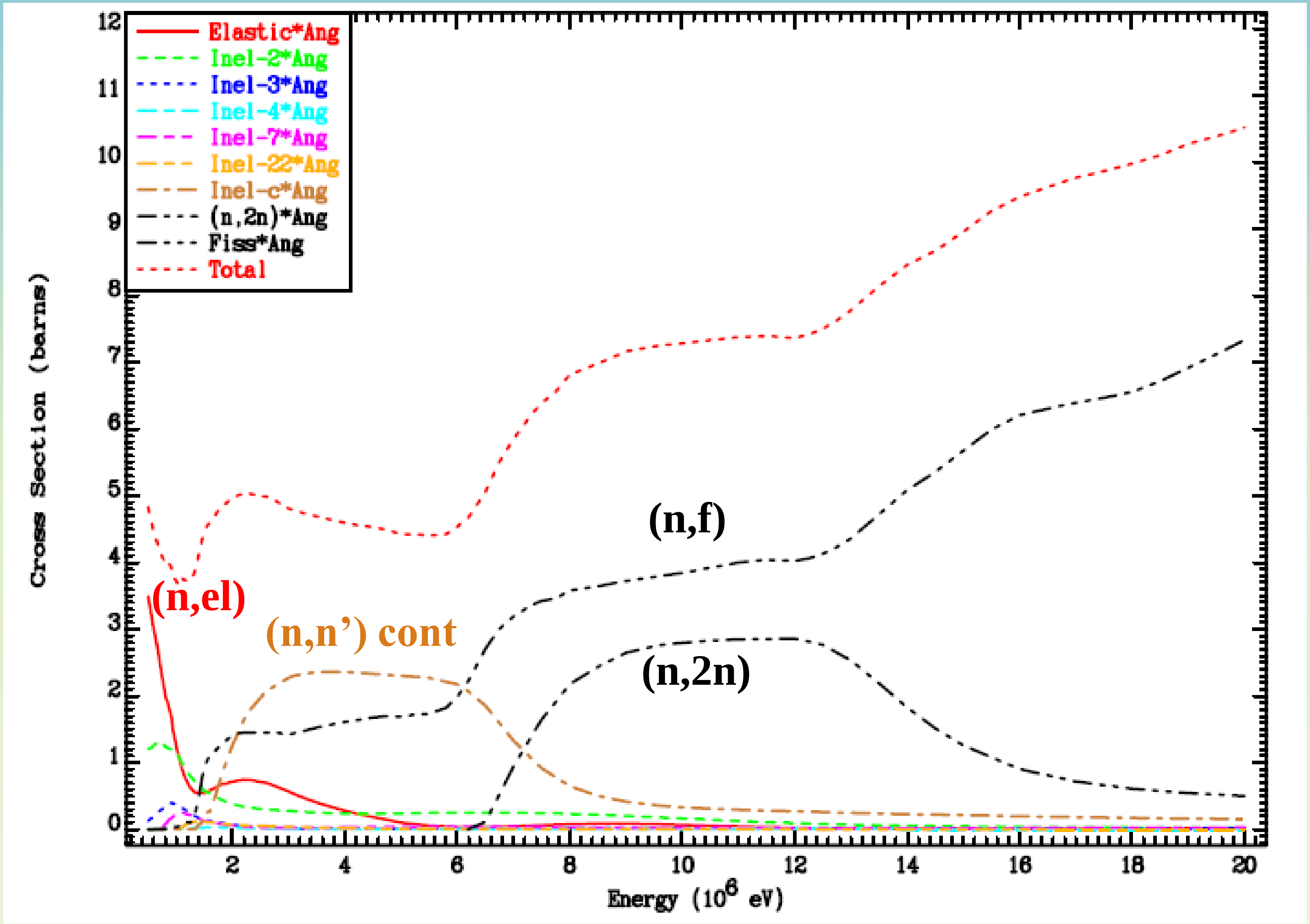
Angle dependent cross sections: 153^0



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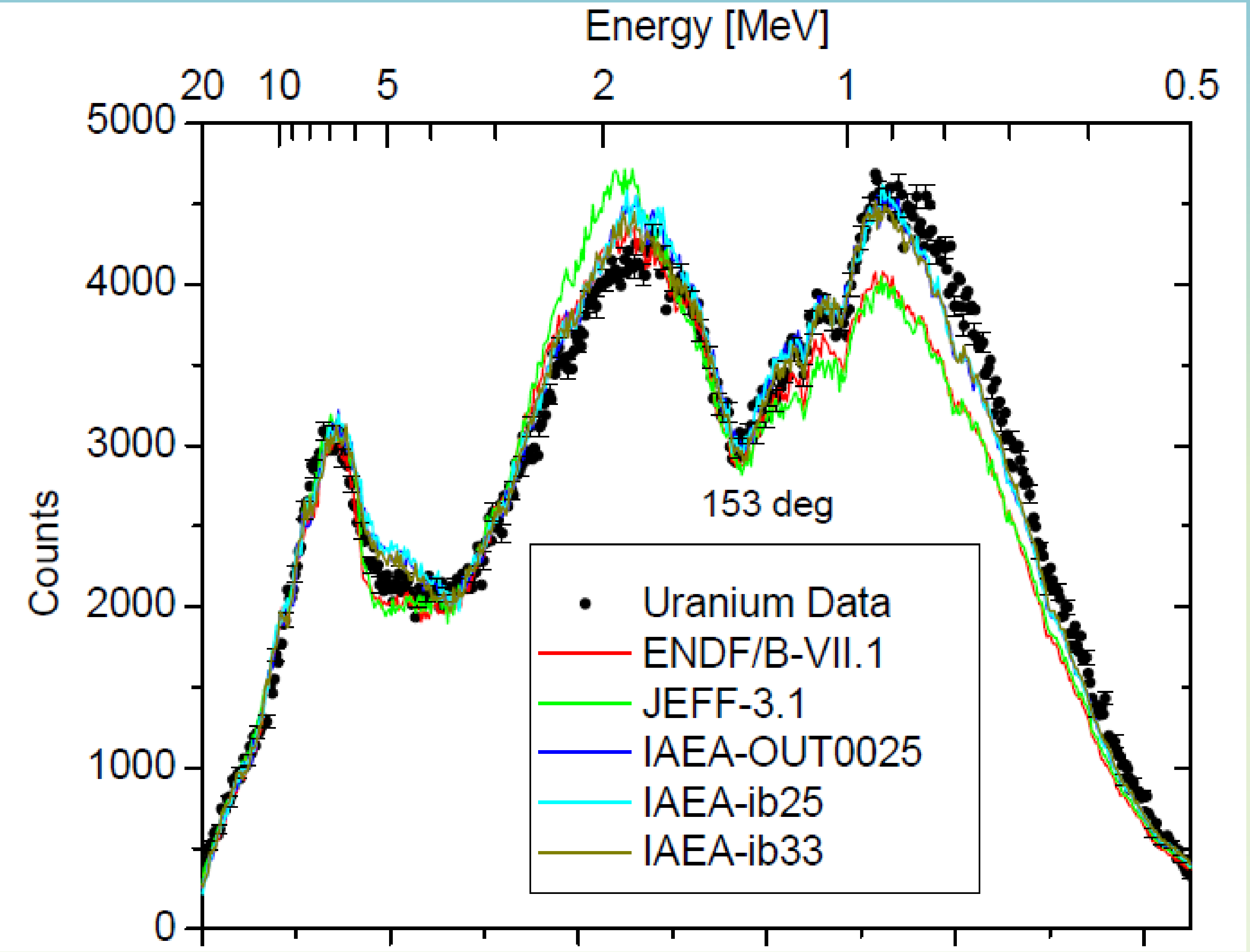
RPI benchmark: 153^0



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Using integral data

k_{eff} & RR

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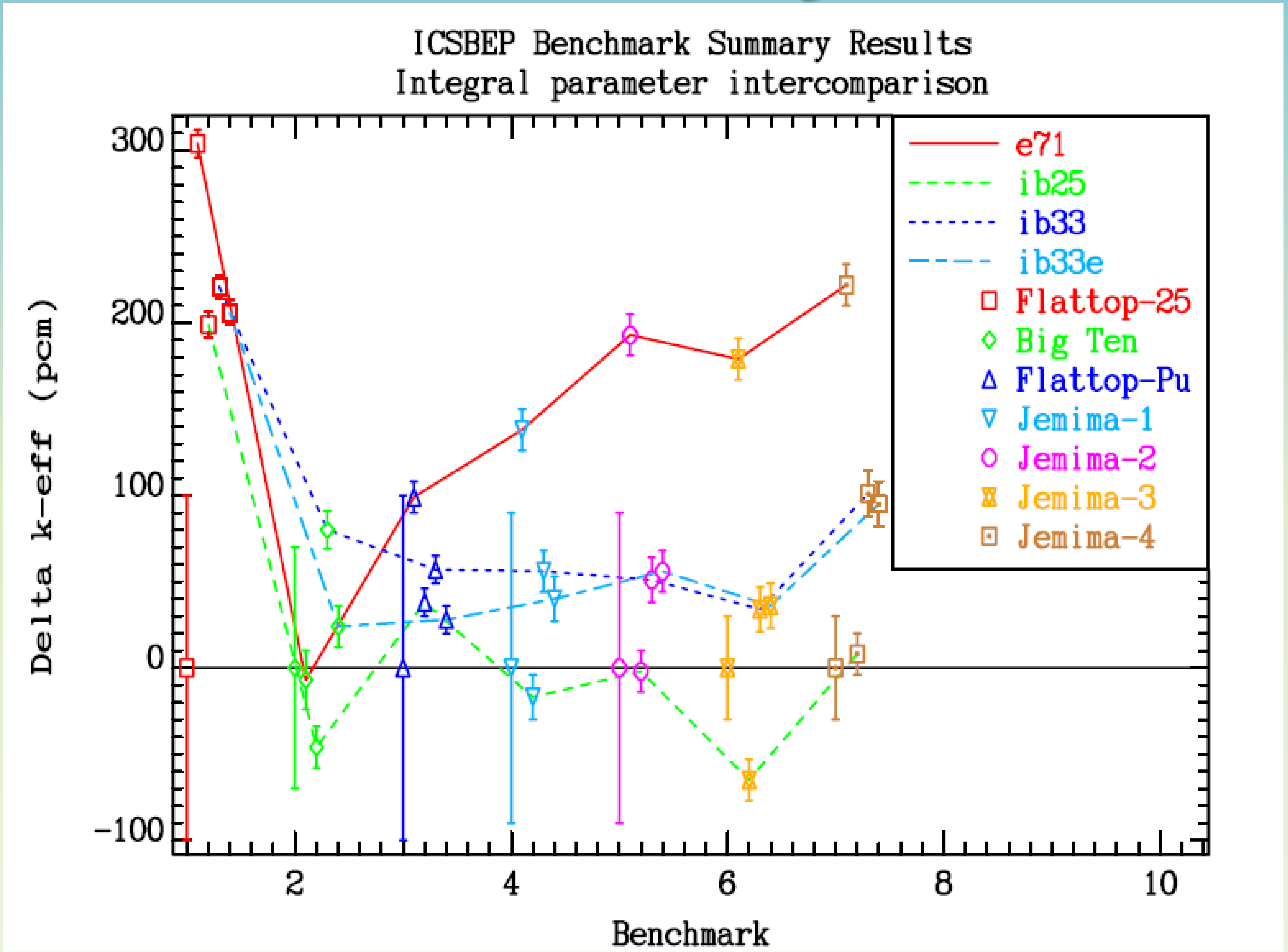
NEA ICSBEP criticality benchmarks



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SPECTRAL INDICES	BENCHMARK	Relative Unc. [%].	JEFF3.1	JEFF3.1.1	IAEA **ib25**	IAEA **ib33**
F8/F5	MASURCA 1A'	2.4%	0.98			
	MASURCA 1B	2.0%	1.01			
	CIRANO ZONA2A	2.4%	1.01		1.017	1,017
	CIRANO ZONA2B	2.8%	1.01			
	MUSE4 (in the lead)	2.0%	0.89			
	SCHERZO	1.5%		0.919	0.973	0.980
	Big-10	1.5%		0.923	0.970	0,974
$^{238}U(n,\gamma)$	PROFIL (12)	0.5%	1.020	1,021		
	PROFIL (23)	0.5%	1.019	1,021		
	PROFIL (29)	0.5%	1,015	1,014		
	PROFIL-2 (A11)	0.3%	1.017	1,017		1,015
	PROFIL-2 (A26)	0.3%	1.020	1,022		1,019
	PROFIL-2 (A39)	0.3%	1.016	1,018		1,015
$^{238}U(n,2n)$	PROFIL-2 (B81)	2.8%	**0.927**		**0.952**	**0,934**
$\Delta\rho$	sphere Pu (Russe)	280 pcm		**+510**	+250	**+240**
	sphere Pu (LANL)	200 pcm		**+230**	-30	**-40**
	sphere U5 (LANL)	200 pcm		**+380**	140	**+170**
ρ	SCHERZO U5.56	300 pcm			-440	**-310**
	Big-10	200 pcm			-110	**+30**
MSK	MASURCA 1B	250 pcm		+450	+327	+330
	PRE-RACINE 1	250 pcm		+420	+490	+530
	PRE-RACINE 2A	250 pcm		+380		+530
	PRE-RACINE 2B	250 pcm		+360		+490
	RACINE 1A	250 pcm		-30	+130	+140
EOLE	UH1.2			**+433**	+354	**+320**

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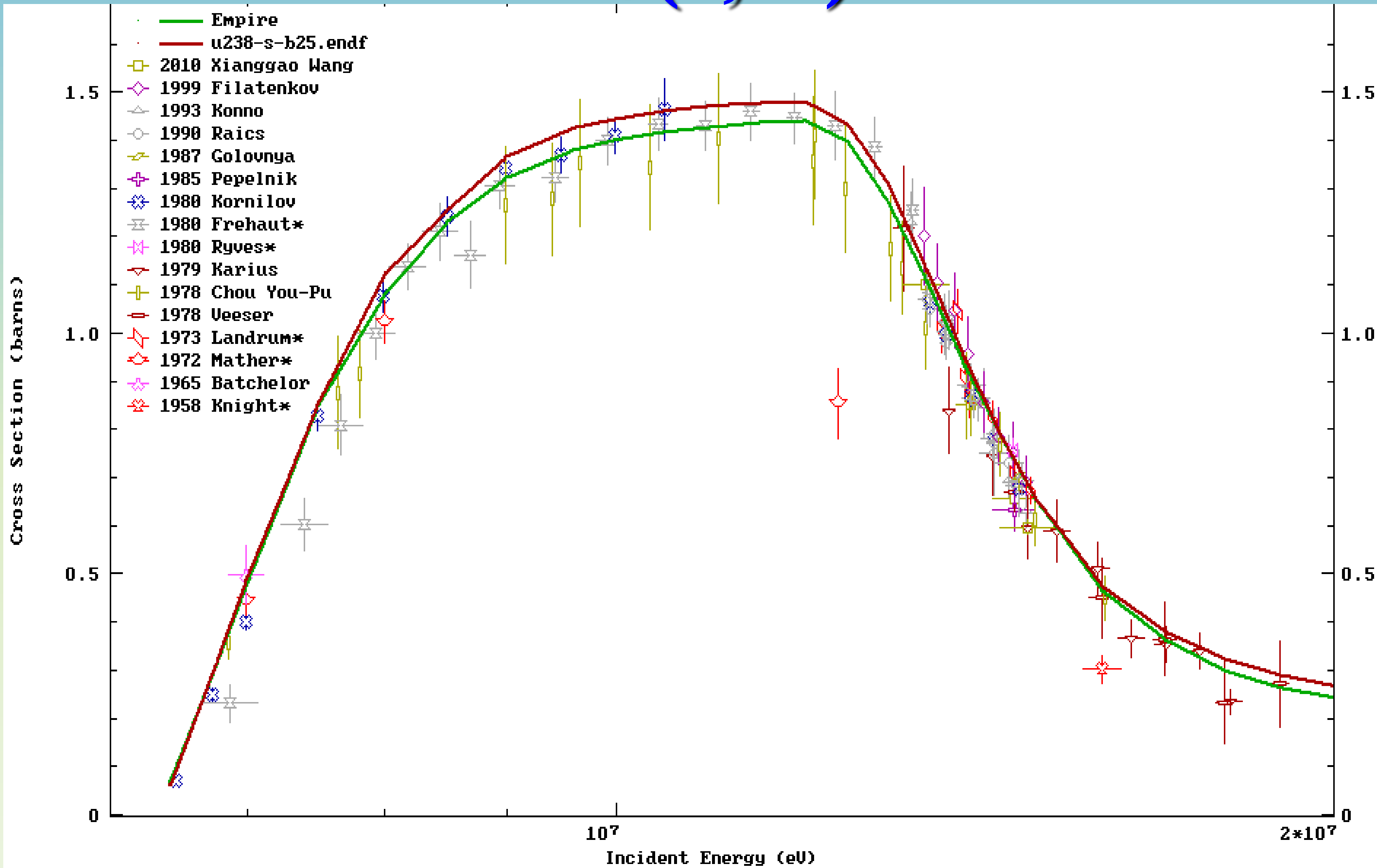
$^{238}U(n,2n)$



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SUMMARY: new ^{238}U evaluation

Better physics:

- ❑ Dispersive CC OMP coupling all levels up to E_n=1 MeV
- ❑ Advanced Hauser-Feshbach treatment includes:
  - CN anisotropy, direct effects on the CN emission
  - Multi-humped fission barrier with absorption (fitted to STDs)
- ❑ Capture / fission follow 2006 IAEA STDs
- ❑ Elastic/Inelastic guided by new RPI "quasi-integral" data

Improved performance:

- ❑ ICSBEP criticality benchmarks including Reaction Rates

Better physics lead to improved performance !

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CHALLENGES

- Apply learned lessons to fissile nuclei including:
  - DCCOMP with multiple band coupling
  - Advanced Hauser-Feshbach treatment

  Leading to changes in the elastic/inelastic scattering
- Impact of fissile PFNS on benchmarks
- Impact of new evaluation on other isotopes (interdependence of benchmarks)

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Thanks for your attention !

(*) CIELO = heaven (in Spanish/Italian)

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