

Neutron resonance densities and neutron strength functions for RIPL-3

A.V.Ignatyuk

Institute of Physics and Power Engineering, Obninsk

- Brief history
- Evaluation approaches
- Road from RIPL-1 to RIPL-3
- Neutron strength functions
- Nuclear level density systematics
- Conclusions



Oslo, 11-15 May 2009

Main compilations of neutron resonance spacings

- A.Gilbert, A.Cameron. *Canad. J. Phys.*, 43 (1965) 1446;
- A.Malyshev. *Nuclear Level Density and Structure of Atomic Nuclei (Russian)*, M., Atomizdat, 1969 ;
- M.Baba. *Nucl. Phys.*, A159 (1970) 625;
- W.Dilg et al., *Nucl. Phys.*, A217 (1973) 269
- G.Rohr et al., in: *Proc. Meeting on Neutron Cross Sections of Fission Products*, (Bologna, 1979), Eds. C.Coceva, G.Panini., NEANDC(E)-209, p. 197.
- S.Mughabghab et al. *Neutron Cross Sections*, NY, Academic Press, v. 1A, 1981 & v. 1b, 1984.
- A.S.Ilinov et al., *Nucl. Phys.*, A543 (1992) 517.
- T.Belanova et al., *Radiative Neutron Capture – Handbook (Russian)*, M., Energoatomizdat, 1996.
- G.Reffo et al., *Contribution to RIPL-1*, 1996.
- Huang Zhongfu et al., *Contribution to RIPL-1*, 1996.
- A.Ignatyuk, in: *Low Energy Neutron Physics*, Berlin, Springer, 2000, v.16A, part 2, 11-1.
- A.Ignatyuk, *Contribution to RIPL-2*, 2002; TECDOC-1506, IAEA, Vienna, 2006.
- S.Mughabghab, *Atlas of Neutron Resonances*, Amsterdam-Tokyo, Elsevier, 2006.



Uncertainties of the mean value estimations:

$$\delta\bar{N} = 1/\sqrt{N}$$

for the normal distribution,

$$\delta\bar{D} = \frac{.45\sqrt{\ln N + 2.18}}{N} \approx \frac{1}{N}$$

for the Wigner distribution,

$$\delta\bar{S} = \sqrt{2/N}$$

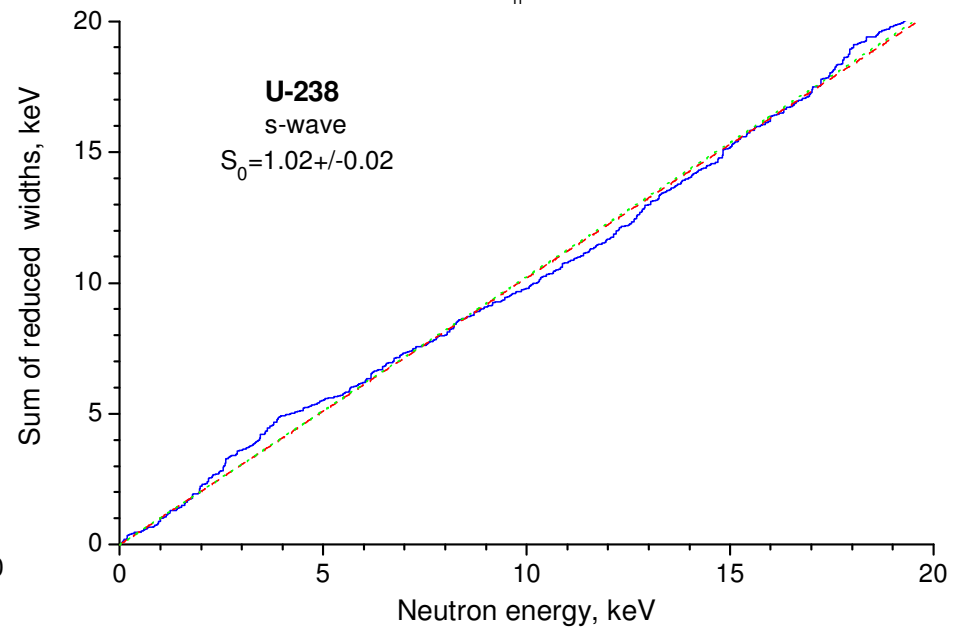
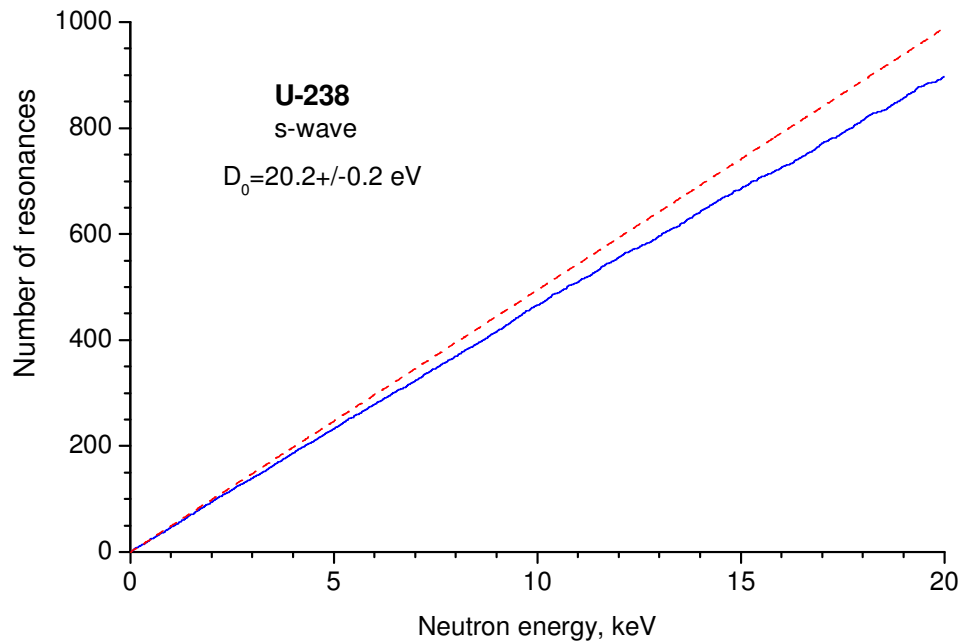
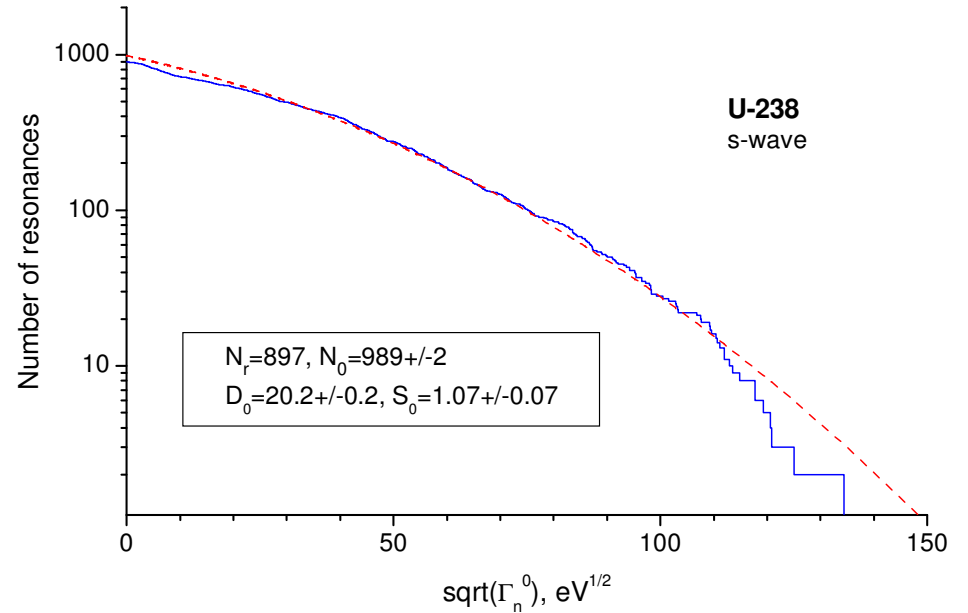
for the Porter-Thomas distribution,

where N is a number of events (resonances).



Analysis of the resonance parameters for ^{238}U

The set of resonances at the energy region up to 20 keV contains 898 s-wave resonances, 849 p-wave resonances with $J=1/2$ and 1565 p-wave resonances with $J=3/2$ [L.Leal et al., Nucl. Data for Science and Technology, Santa Fe, 2004, p.276].

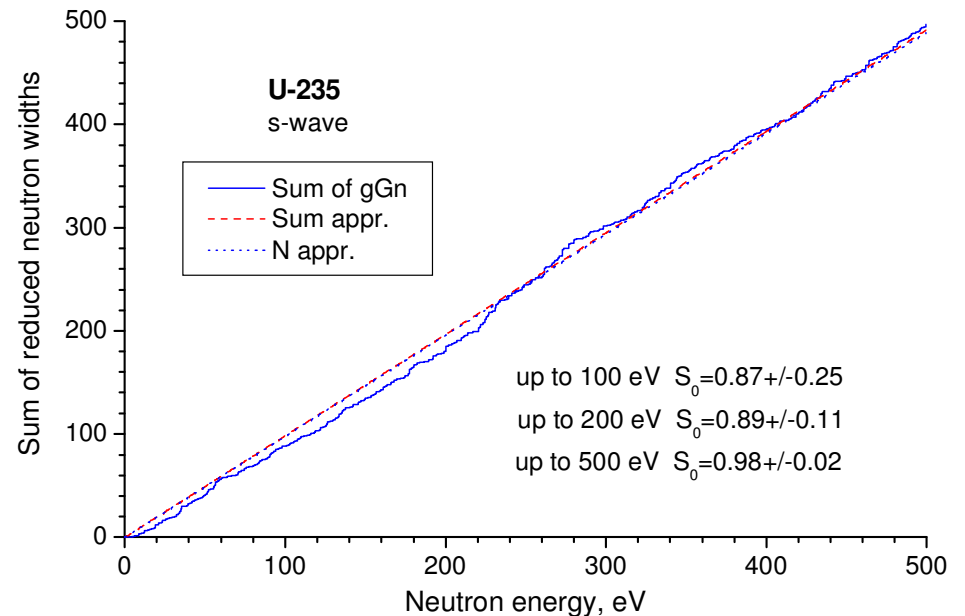
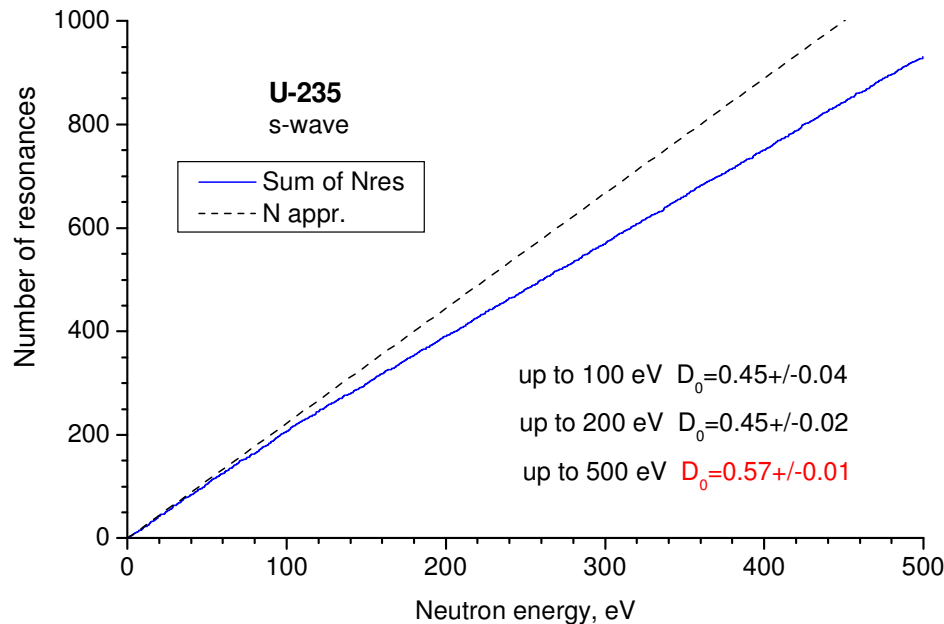
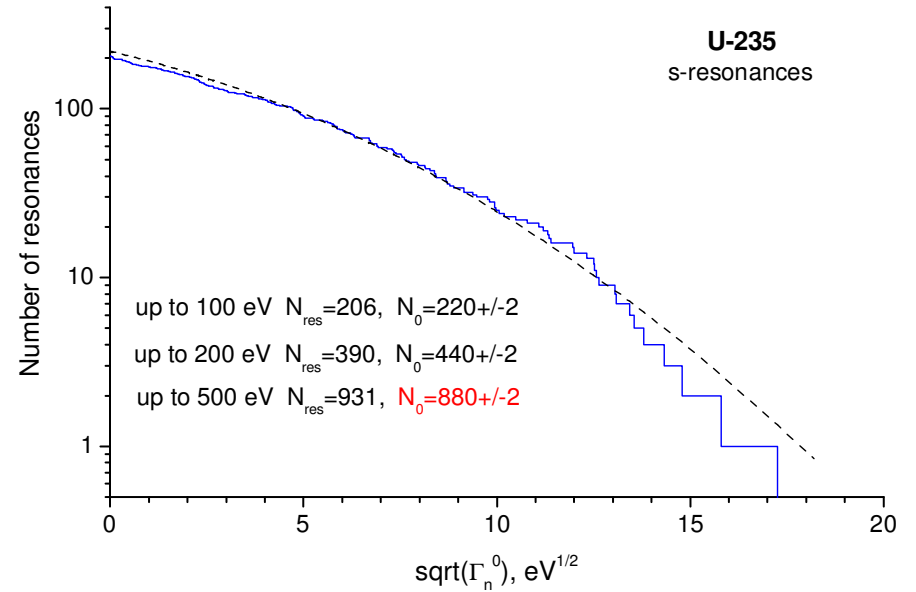


Average resonance parameters for ^{238}U :

	D_0 , eV	D_1 , eV	S_0 , 10^{-4}	S_1 , 10^{-4}
1965, Gil.-Cam.	17.7 ± 0.7	--	--	--
1979, Rohr et al.	21.5 ± 2.2	--	1.02 ± 0.16	--
1984, Mughabghab	20.9 ± 1.1	7.2 ± 0.4	1.2 ± 0.1	1.7 ± 0.3
1986, Ignatyuk et al.	21.7 ± 0.9	7.3 ± 0.5	1.15 ± 0.12	1.7 ± 0.5
1996, Beijing, RIPL-1	21.0 ± 0.05	--	0.93 ± 0.06	--
2002, RIPL-2 (10 keV)	20.8 ± 0.3	7.7 ± 1.0	1.03 ± 0.08	1.6 ± 0.4
2004, Leal et al., (20 keV)	--	--	1.07 ± 0.07	1.71 ± 0.07
2006, Mughabghab	20.26 ± 0.72	7.42 ± 0.23	1.29 ± 0.13	2.17 ± 0.19
2007, RIPL-3	20.3 ± 0.6	7.7 ± 0.3	1.03 ± 0.08	1.6 ± 0.2

Analysis of the resonance parameters for ^{235}U

The set of resonances at the energy region up to 2.25 keV contains 849 s-wave resonances with $J=3$ and 1565 s-wave resonances with $J=4$ [L.Leal et al., Report ORNL/TM-13516, 1997]. It was recognized that the energy range below 100 eV should be used to analyze the statistical properties of resonances.



Average resonance parameters for ^{235}U :

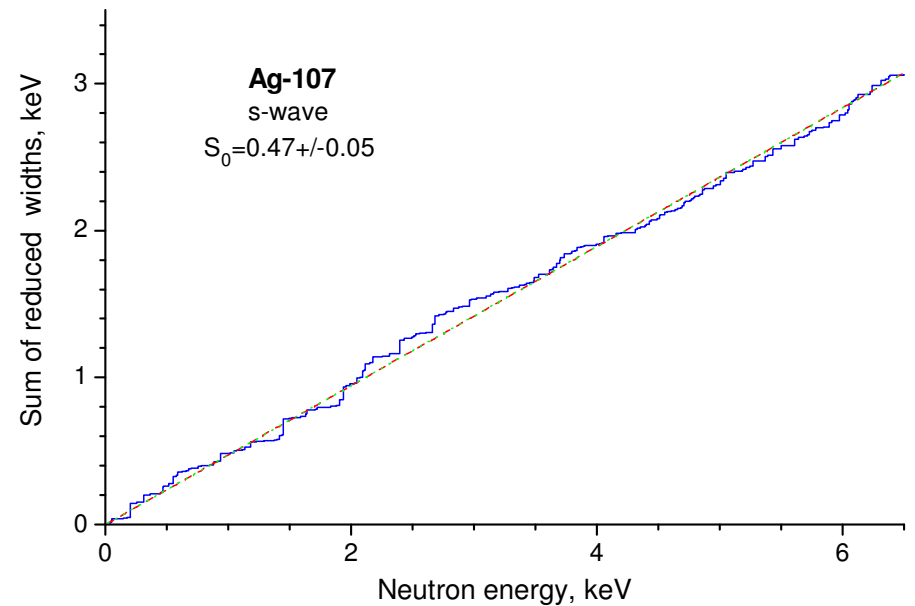
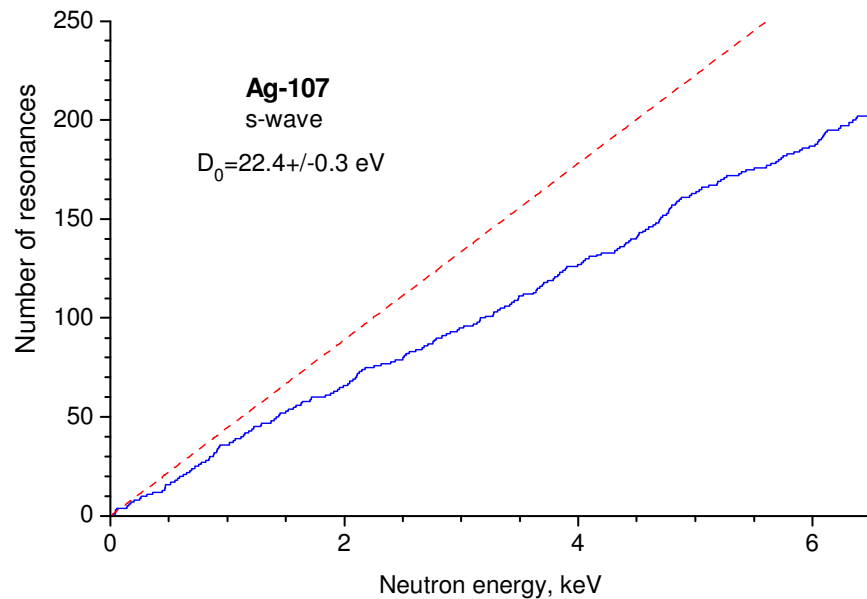
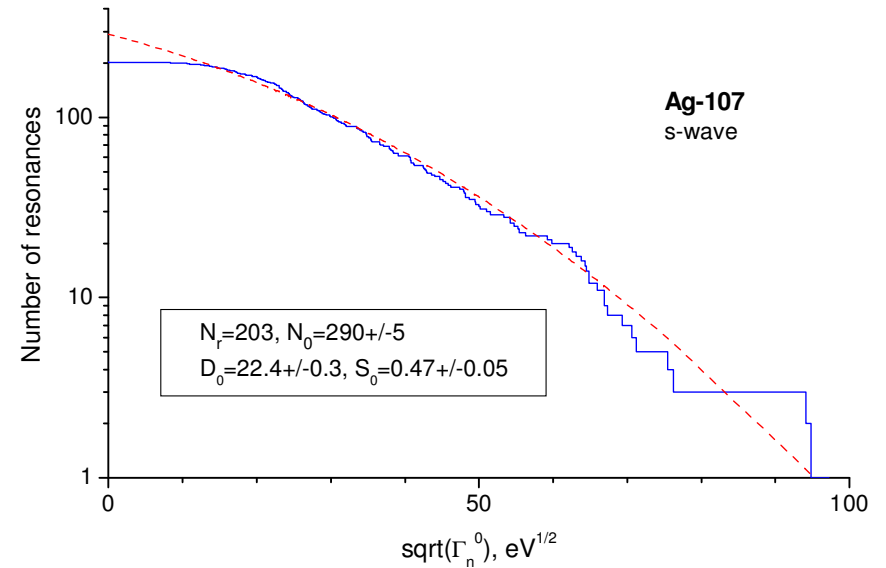
	D_0, eV	$S_0, 10^{-4}$	$S_1, 10^{-4}$
1965, Gil.-Cam.	0.65 ± 0.03	--	--
1979, Rohr et al.	0.59 ± 0.06	1.90 ± 0.15	--
1984, Mughabghab	0.44 ± 0.06	1.0 ± 0.1	$1.8 \pm 0.3^*$
1986, Ignatyuk et al.	0.43 ± 0.01	0.96 ± 0.12	$1.8 \pm 0.3^*$
1996, Beijing, RIPL-1	0.55 ± 0.02	0.92 ± 0.07	--
2002, RIPL-2	0.43 ± 0.02	0.88 ± 0.08	$1.8 \pm 0.3^*$
2006, Mughabghab	0.49 ± 0.02	0.98 ± 0.07	$1.8 \pm 0.3^*$
2007, RIPL-3	0.45 ± 0.03	$0.98 \pm 0.07^{**}$	$1.8 \pm 0.3^*$

* S_1 is taken from the Froener (1983) analysis of URR

** It is recommended for all region up to 2.25 keV, for the region below 200 eV the value 0.88 ± 0.08 is more correct.

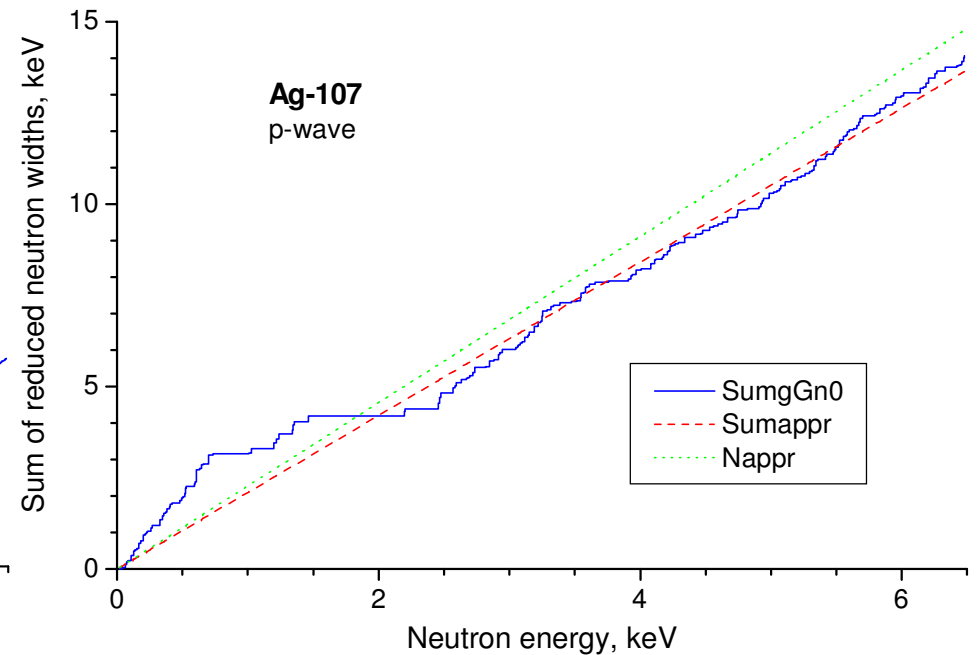
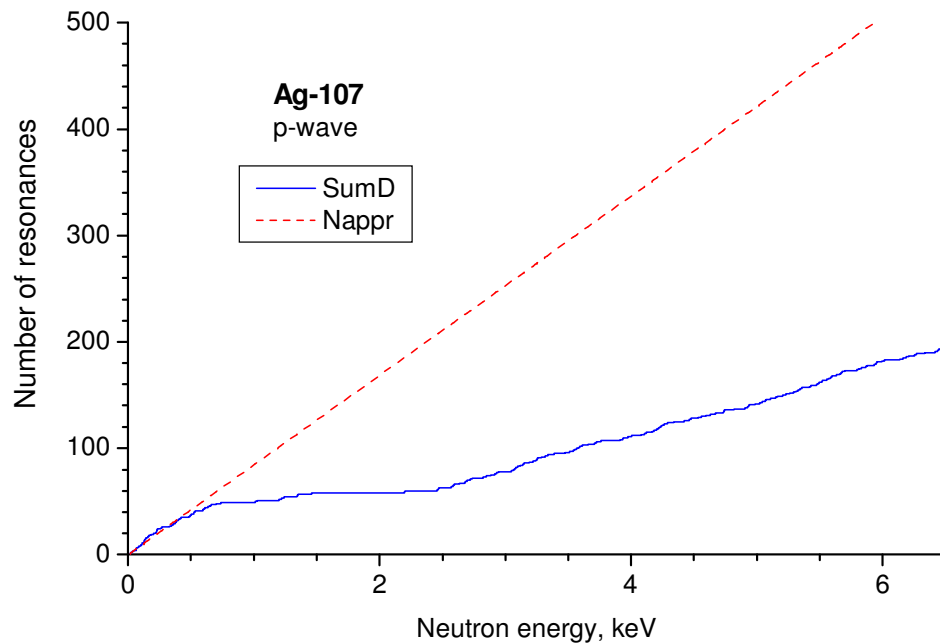
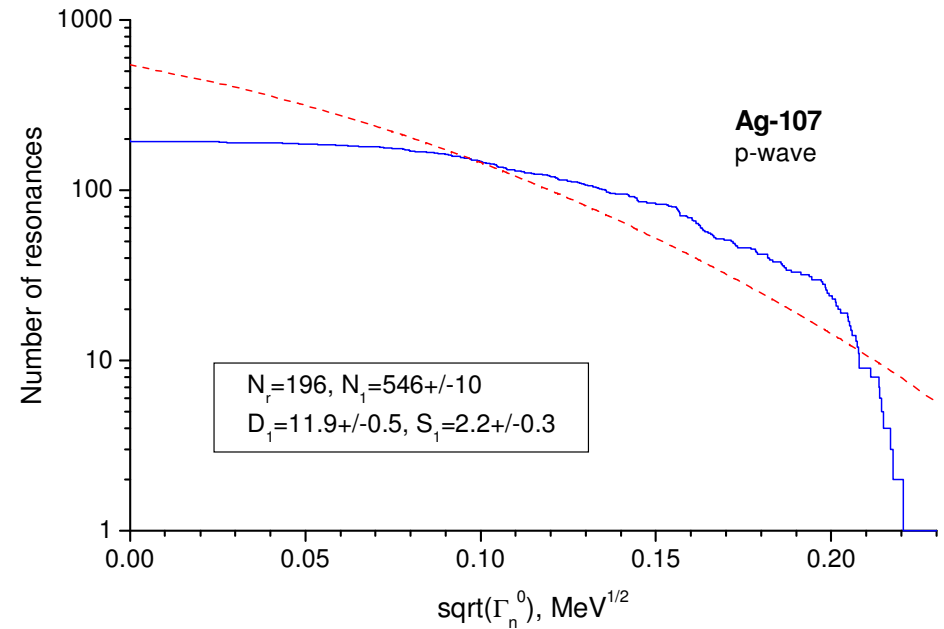
Analysis of the resonance parameters for ^{107}Ag

The set of resonances at the energy region up to 6.5 keV contains 203 s-wave resonances and 196 p-wave resonances, which were inserted into the ENDF/B-VII file from the Mughabghab-2006. It is impossible to describe the PT-distribution with $D_0=14.9\pm 0.6$ eV /Mug2006/.



Analysis of the resonance parameters for ^{107}Ag

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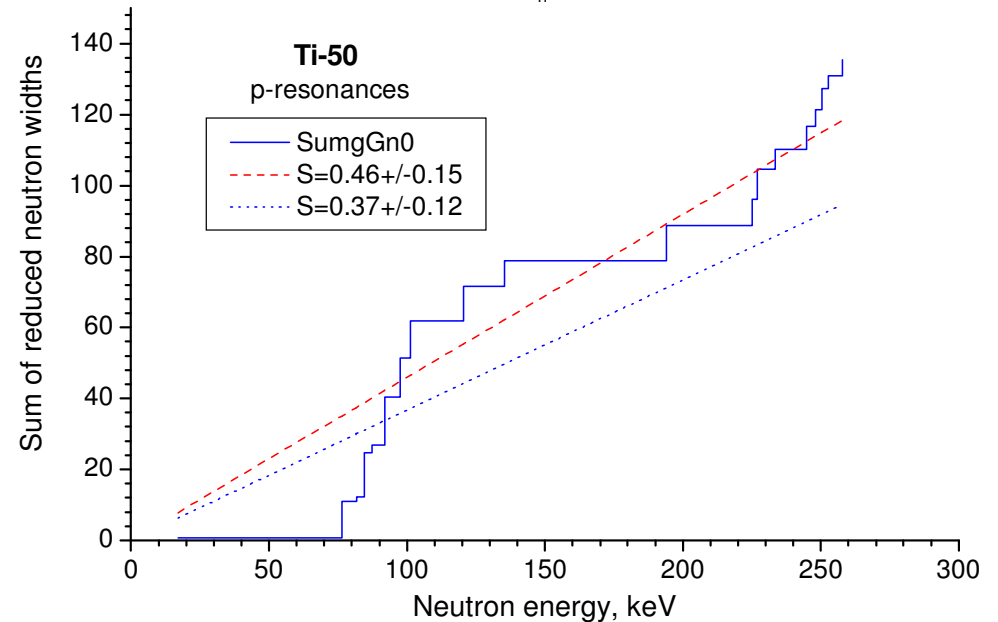
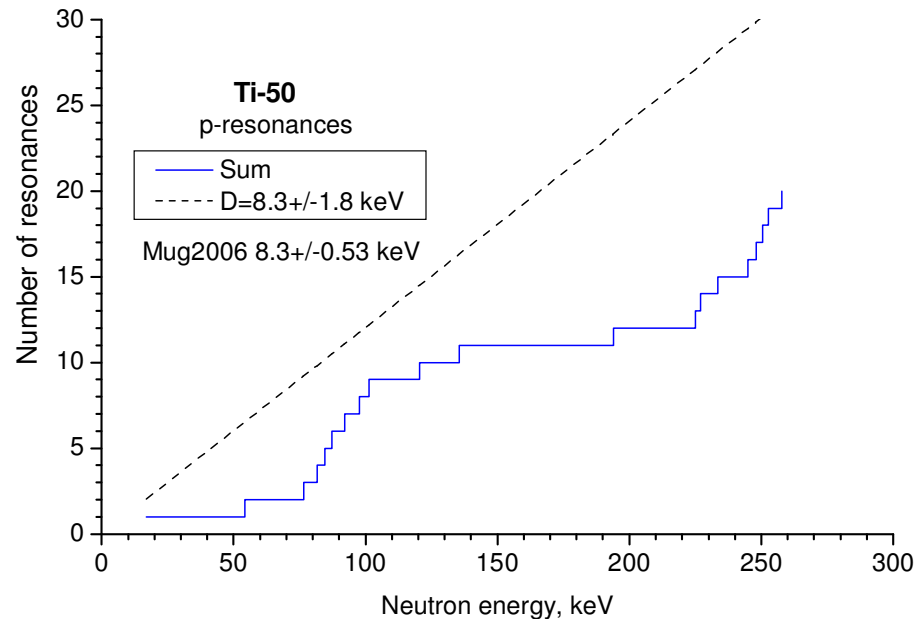
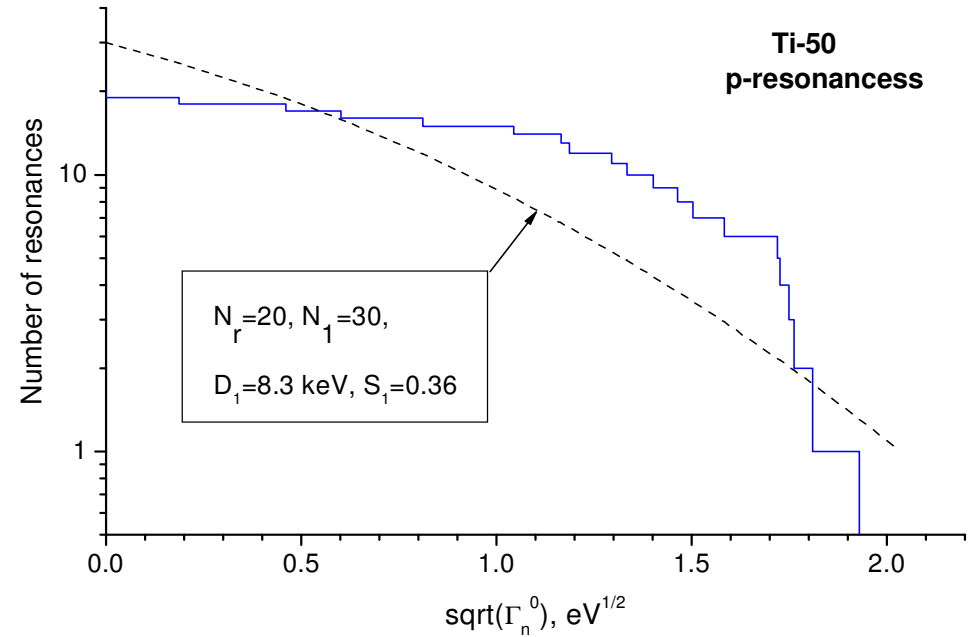


Average resonance parameters for ^{107}Ag :

	D_0 , eV	D_1 , eV	S_0 , 10^{-4}	S_1 , 10^{-4}
1965, Gil.-Cam.	31 ± 6	--	--	--
1979, Rohr et al.	24.0 ± 2.8	--	0.41 ± 0.13	--
1984, Mughabghab	16 ± 3	--	0.38 ± 0.07	3.8 ± 0.6
1986, Ignatyuk et al.	22 ± 2	--	0.42 ± 0.05	3.8 ± 0.5
1996, Beijing, RIPL-1	22.6 ± 0.09	--	0.54 ± 0.04	--
2002, RIPL-2	22.0 ± 0.4	--	0.40 ± 0.06	3.8 ± 0.8
2006, Mughabghab	14.9 ± 0.6	8.49 ± 0.25	0.46 ± 0.05	3.76 ± 0.31
2007, RIPL-3	28 ± 2	10 ± 2	0.46 ± 0.06	4.0 ± 0.6
2008, Mughabghab	23.0 ± 0.8	(priv.com.)		

Analysis of the resonance parameters for ^{50}Ti

The set of resonances contains three s-wave resonances with the energies 56.5, 185.6 and 307.0 keV and about 20 p-wave resonances [Bowman et al., 1962; Garg et al., 1971; Mughabghab et al., 1981].

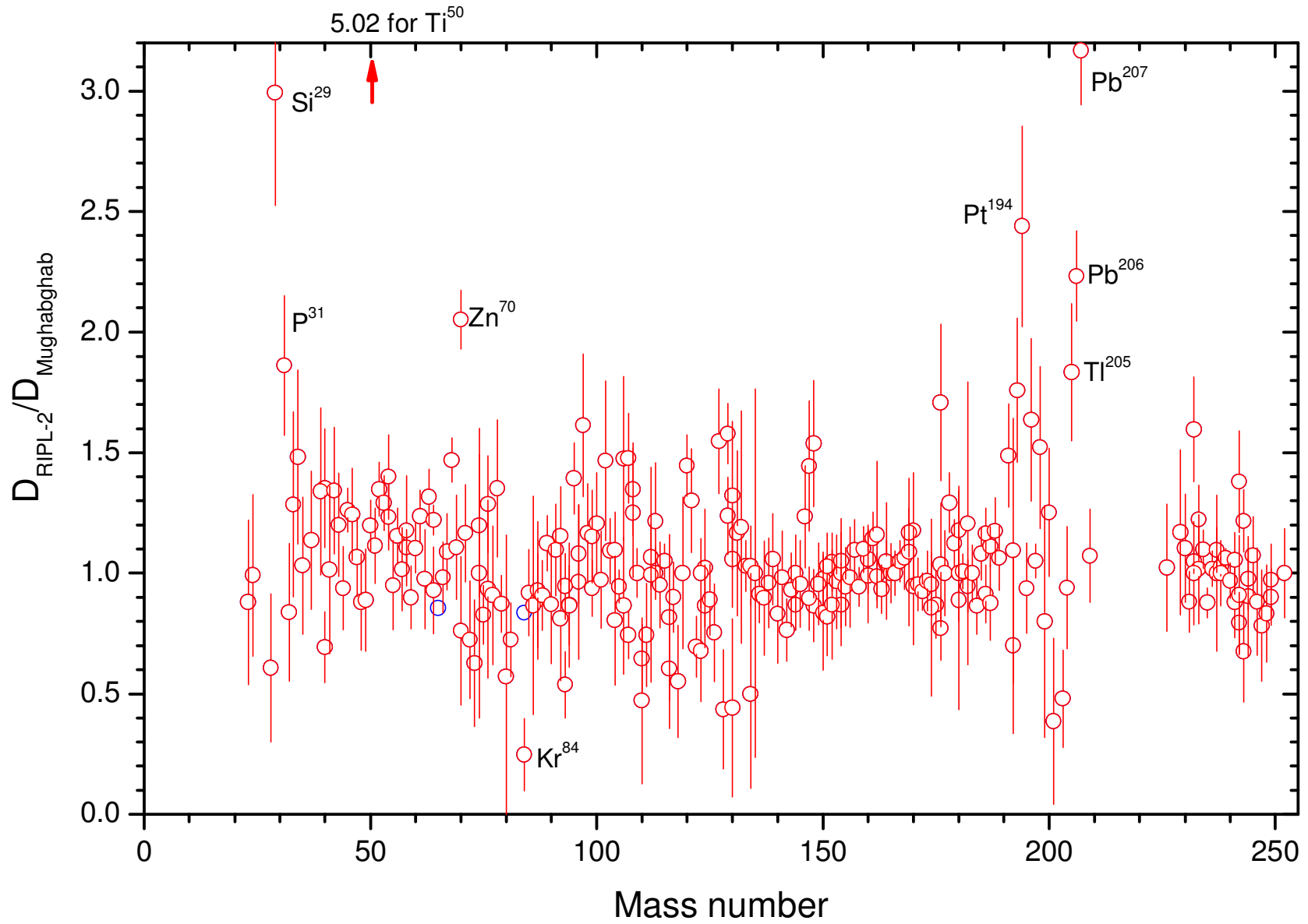


Analysis of the resonance spacing for ^{50}Ti :

The set of resonances for ^{50}Ti contains three s-wave resonances with the energies **56.5, 185.6 and 307.0 keV** and about 20 p-wave resonances. The following estimations for the resonance spacing were made on this basis:

	D_0 , keV	D_1 , keV	S_1 , 10^{-4}
1970, M.Baba	18 ± 6 ($\approx 3D_1$)	--	--
1979, G.Rohr et al.	71 ± 40	--	--
1981, S.Mughabghab	125 ± 70	10 ± 3	0.40 ± 0.17
1986, A.Ignatyuk et al.	Mug81 was accepted for all		
1996, Bologna, RIPL-1	103 ± 42	--	--
1996, Beijing, RIPL-1	84.8 ± 24.4	--	--
2002, RIPL-2	125 ± 70	10 ± 3	0.40 ± 0.17
2006, S.Mughabghab	24.9 ± 1.5 ($\approx 3D_1$)	8.30 ± 0.53	0.54 ± 0.10

Ratios of RIPL-2/Mug_2006 for of the s-resonance spacing





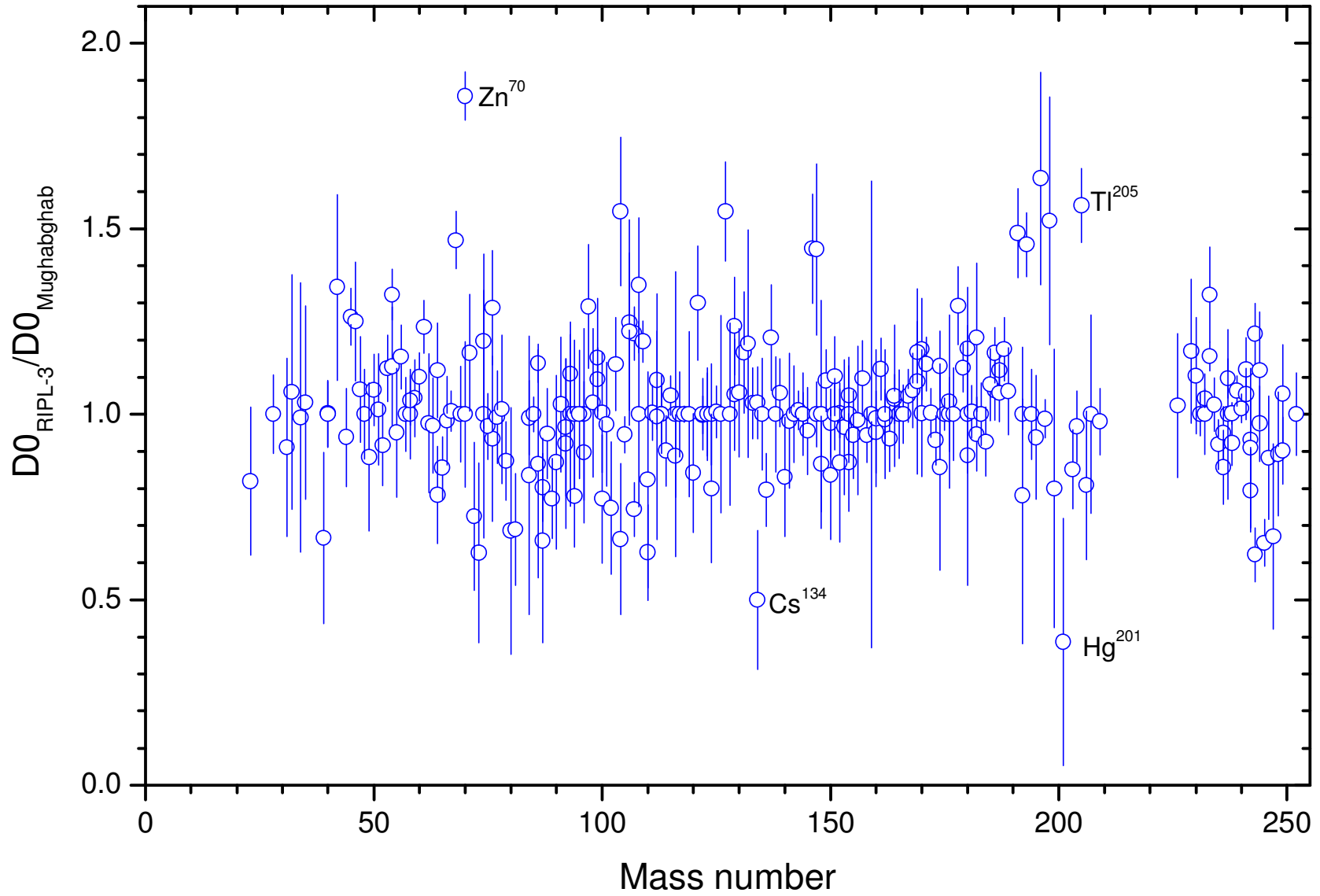
National Nuclear Data Center

BROOKHAVEN
NATIONAL LABORATORY

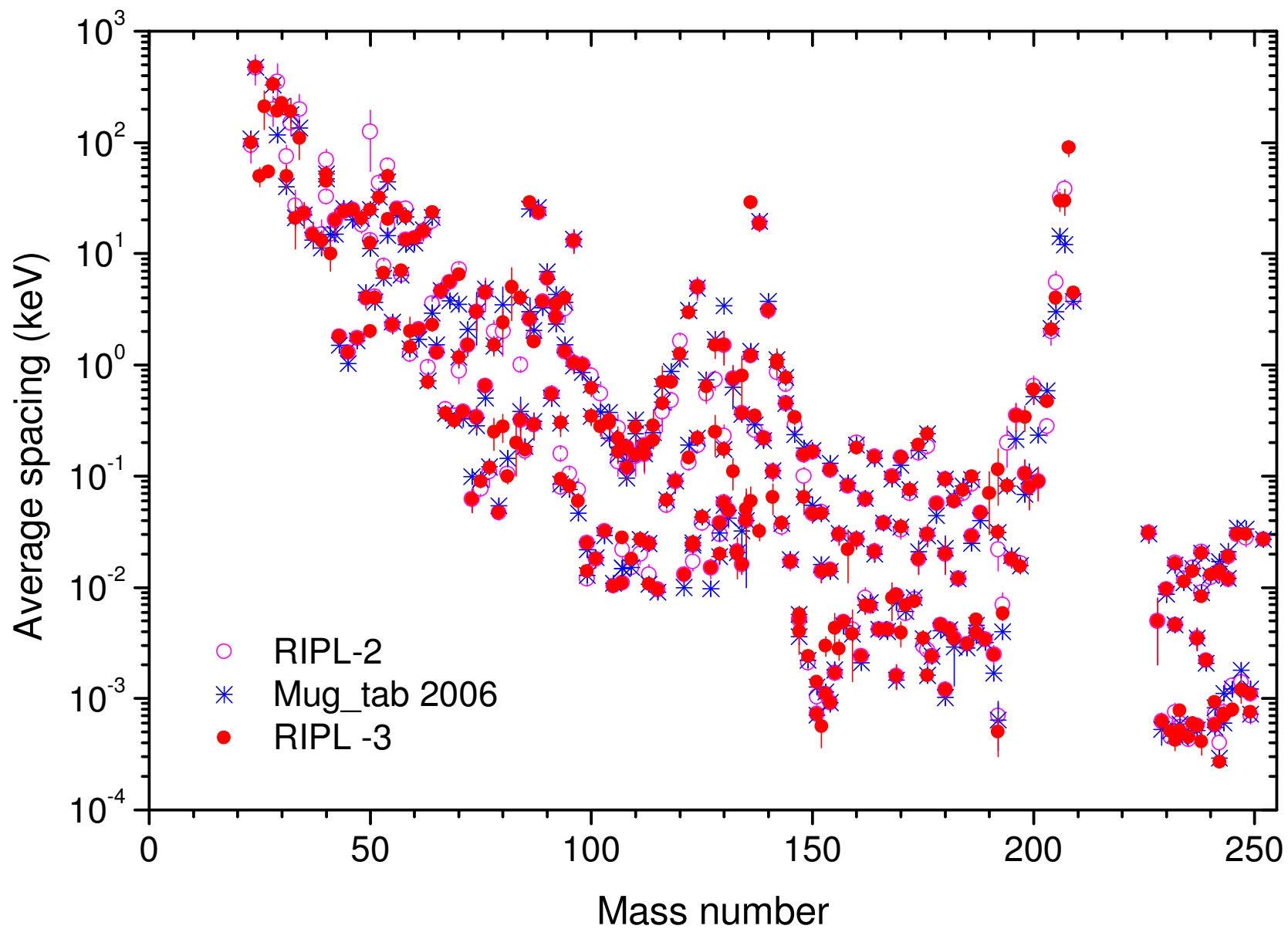
Nuclear Data Week at BNL,
2-7 November 2008



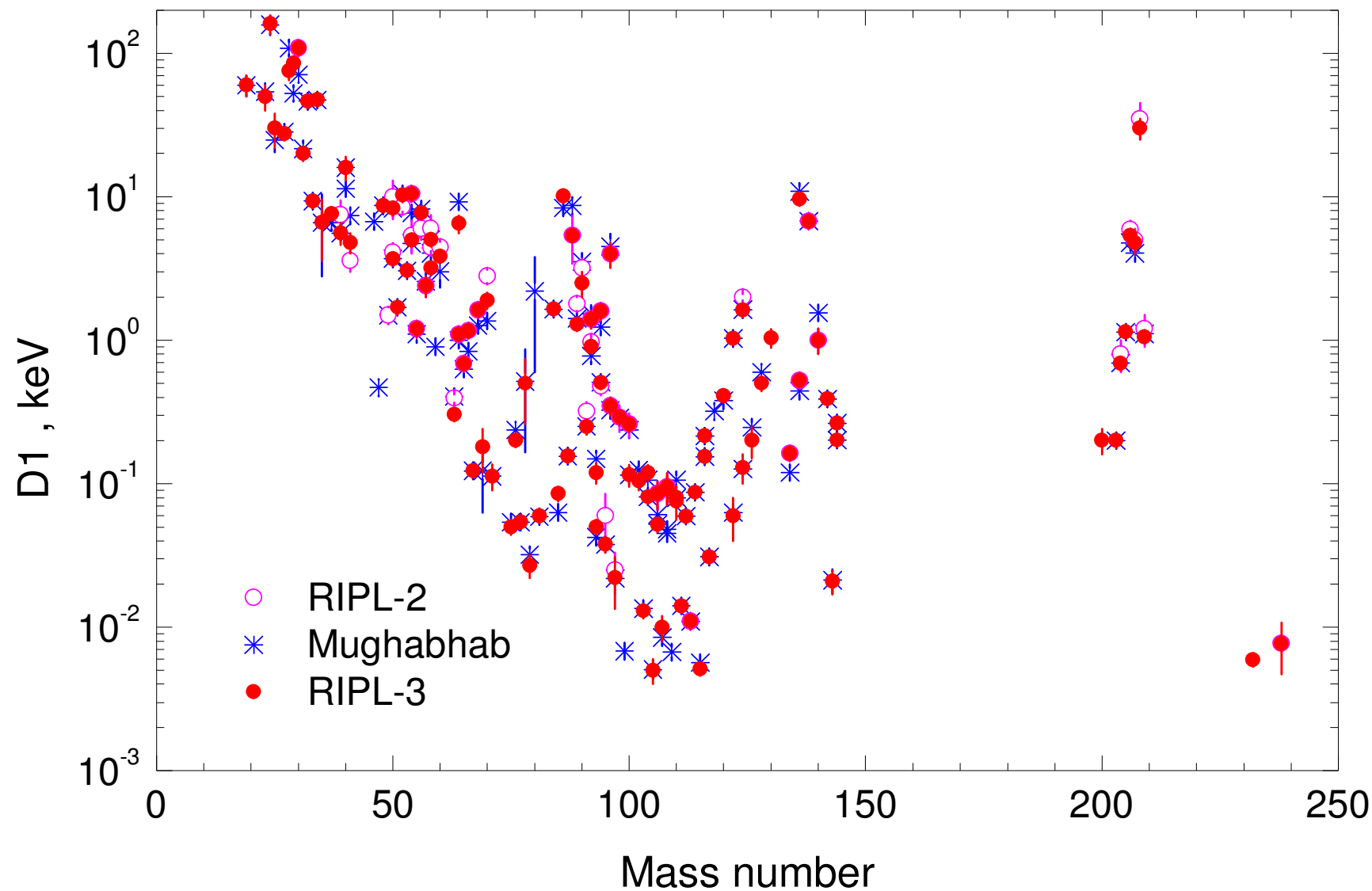
Ratios of RIPL-3/Mug_2006 for of the s-resonance spacing



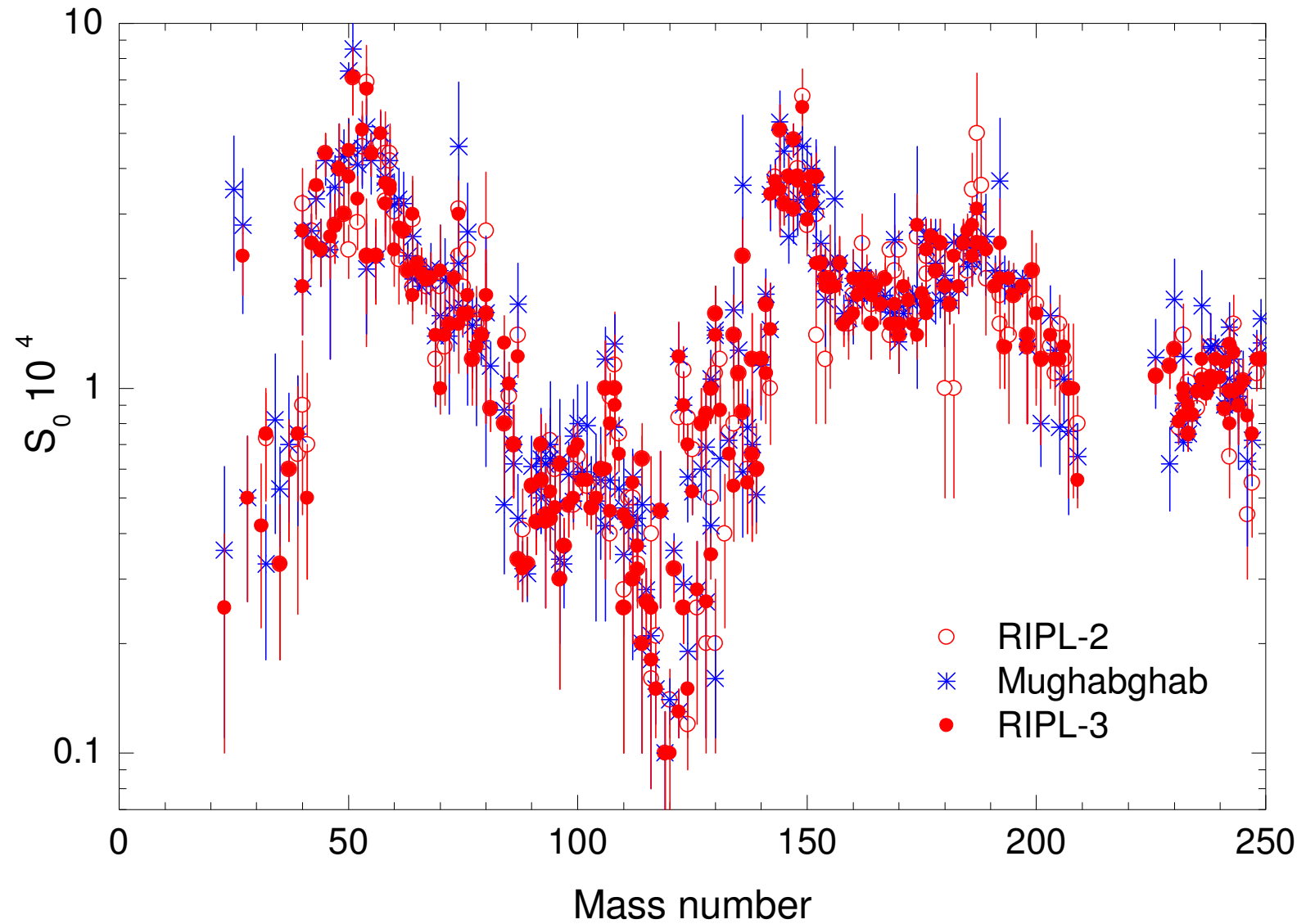
Average spacings of the s-wave resonances



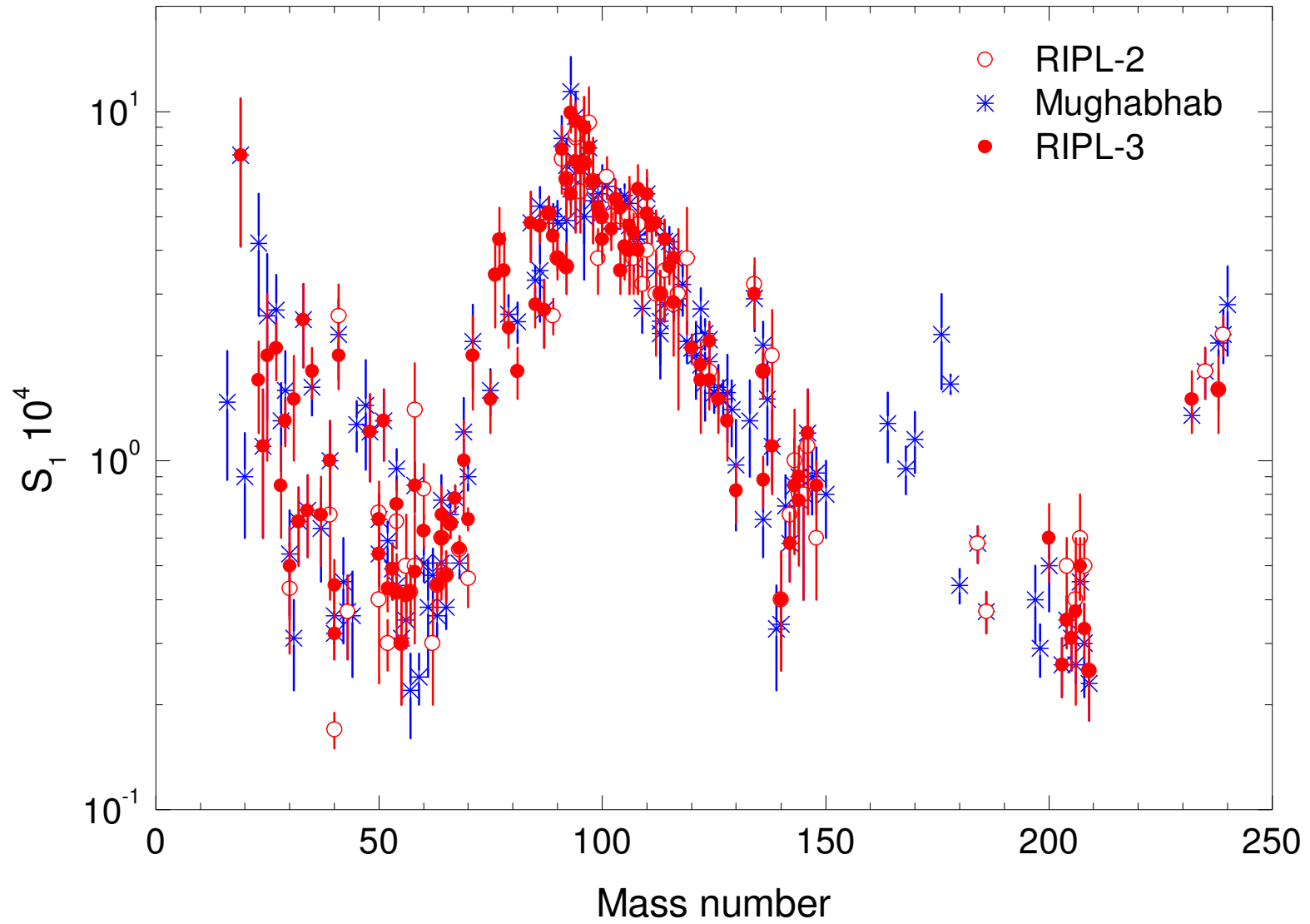
Average spacings of the p-wave resonances



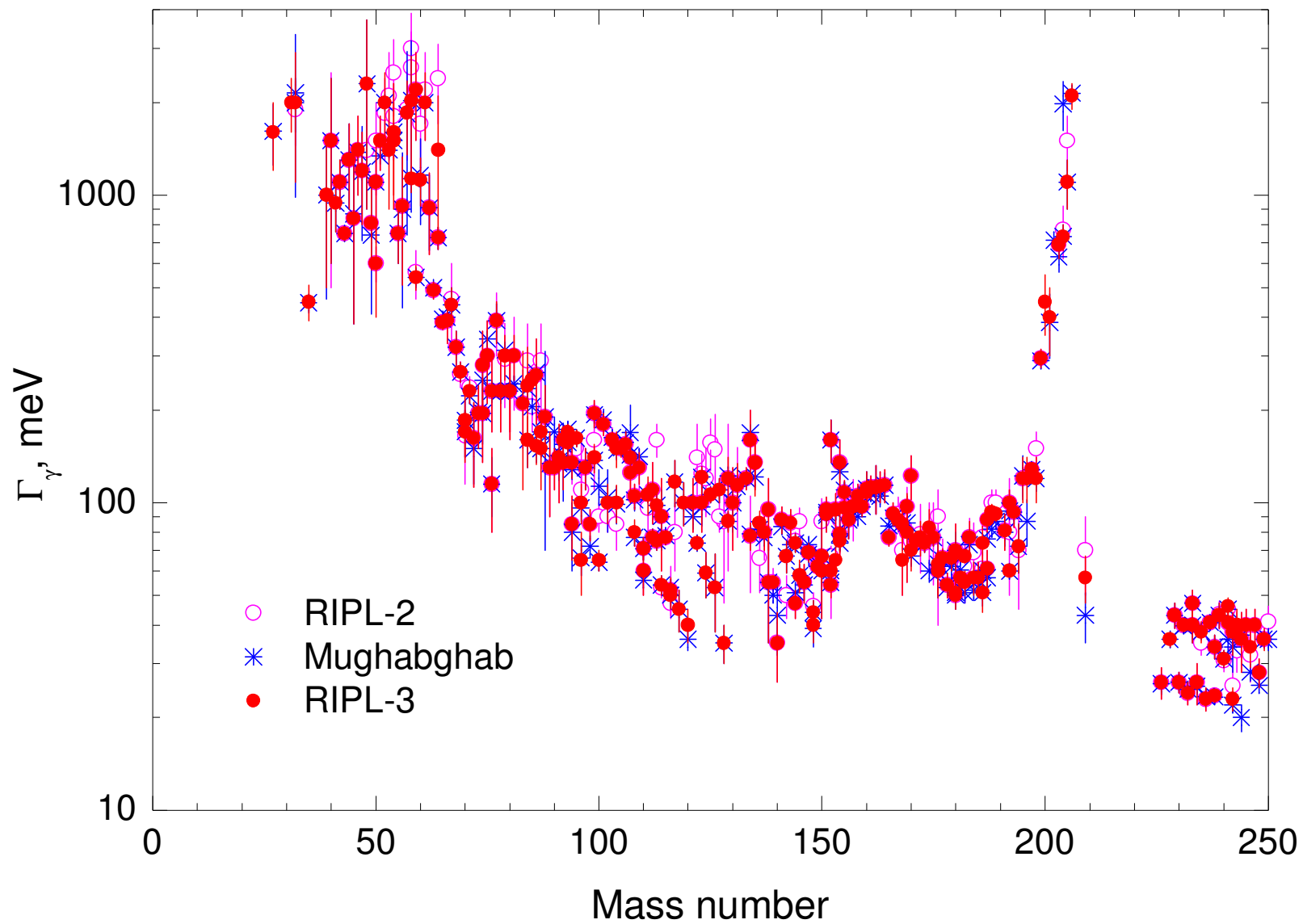
Neutron strength functions for the s-wave resonances



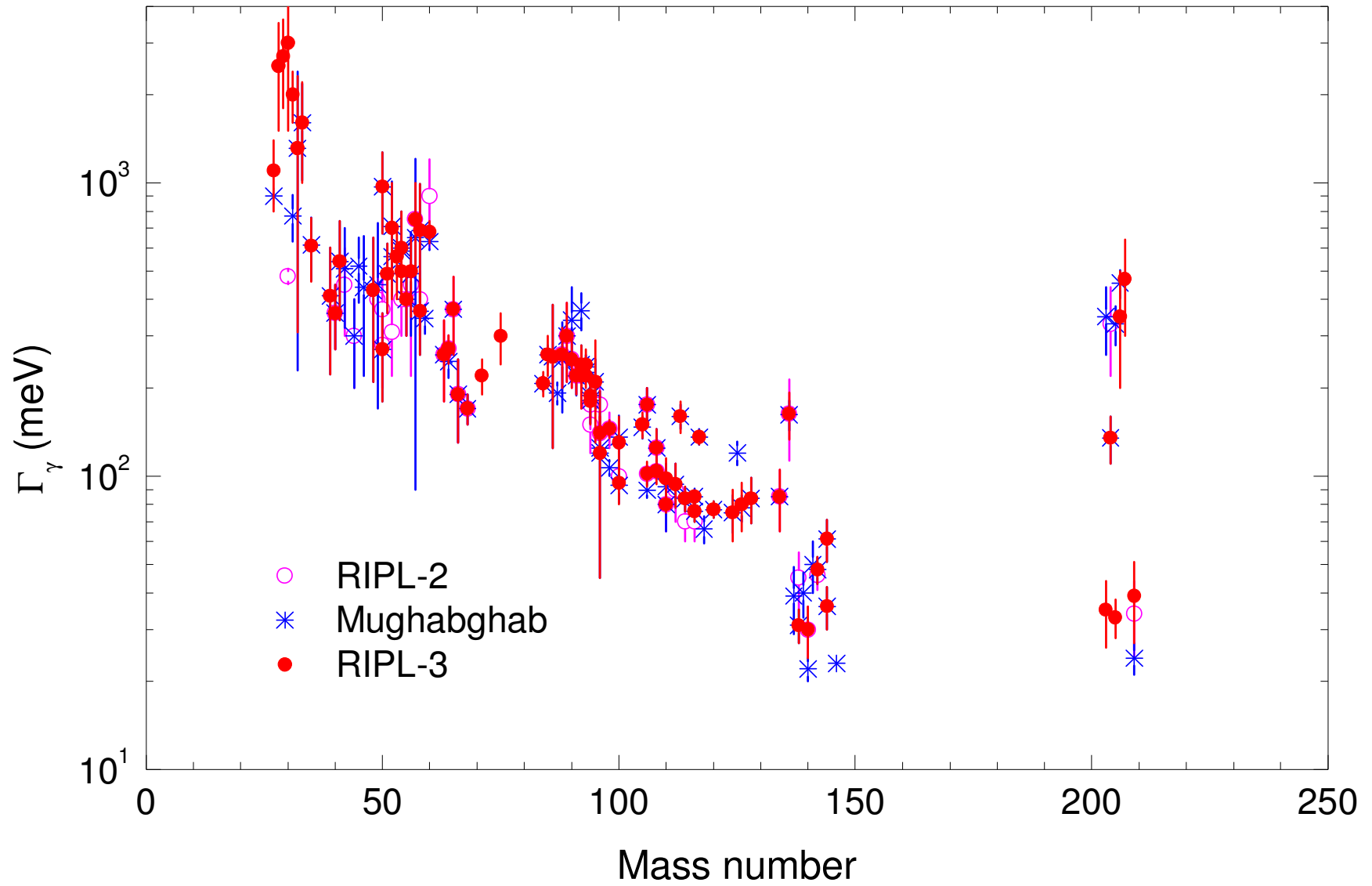
Neutron strength functions for the p-wave resonances



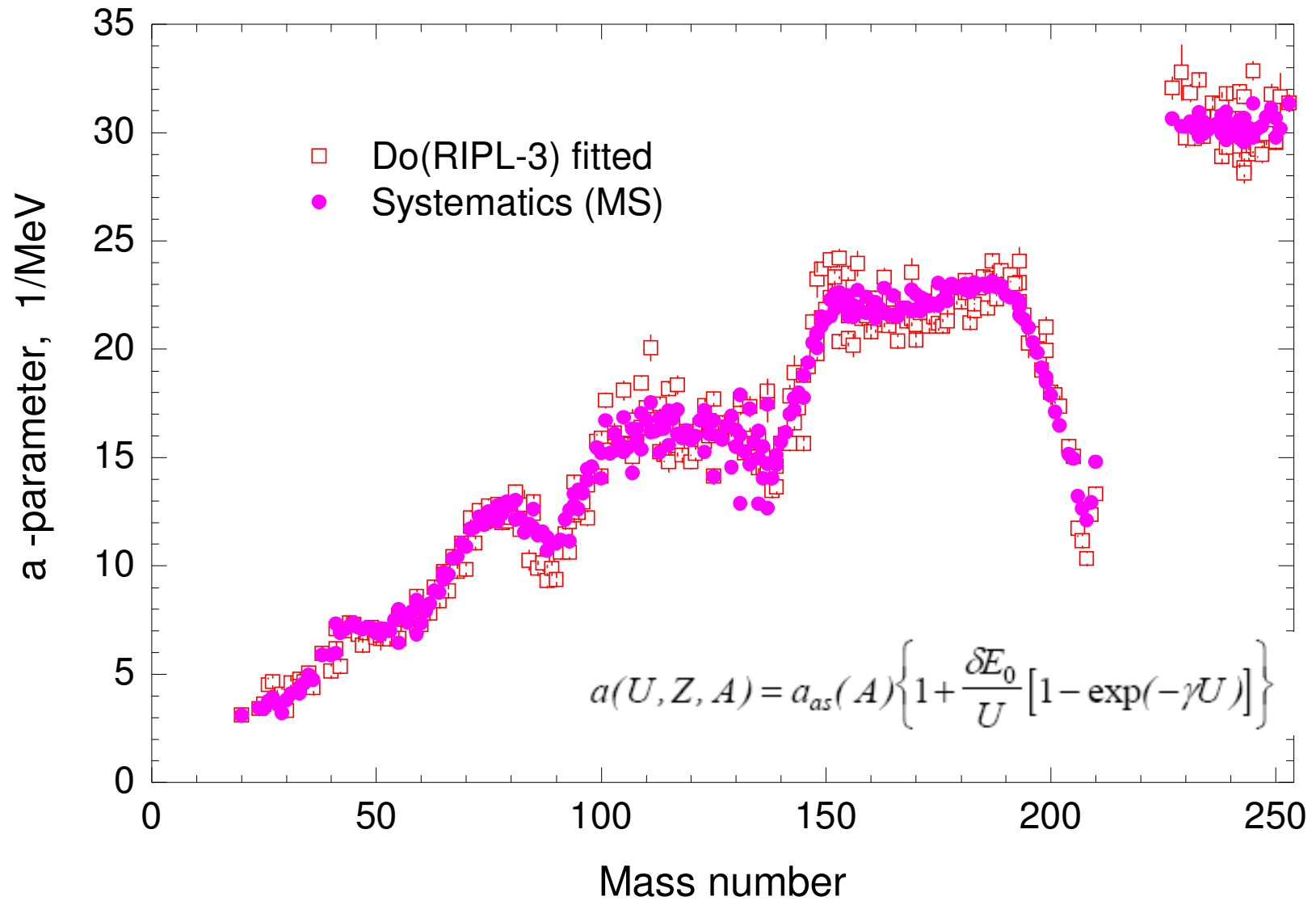
Average radiative widths for the s-wave resonances

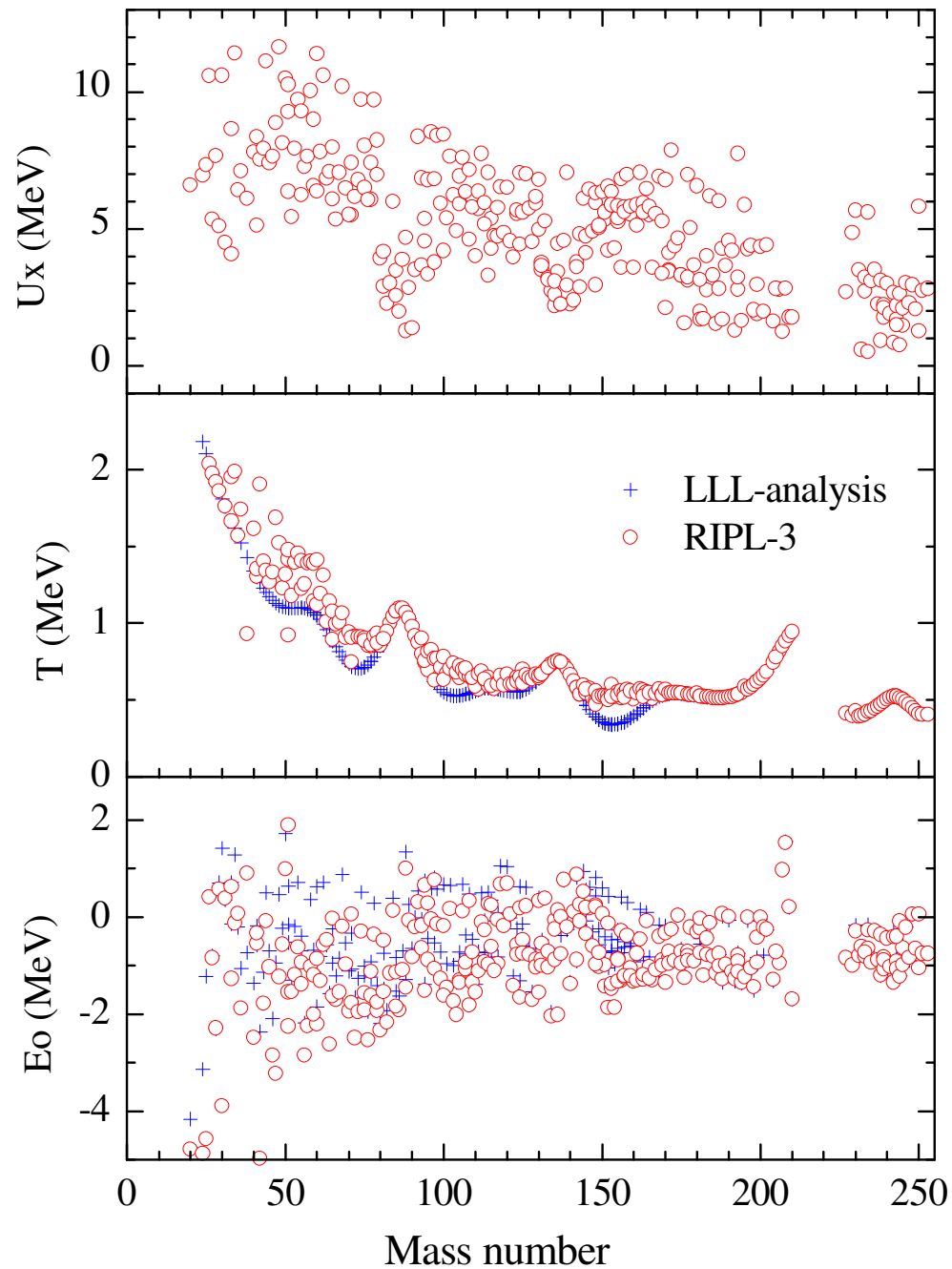


Average radiative widths for the p-wave resonances



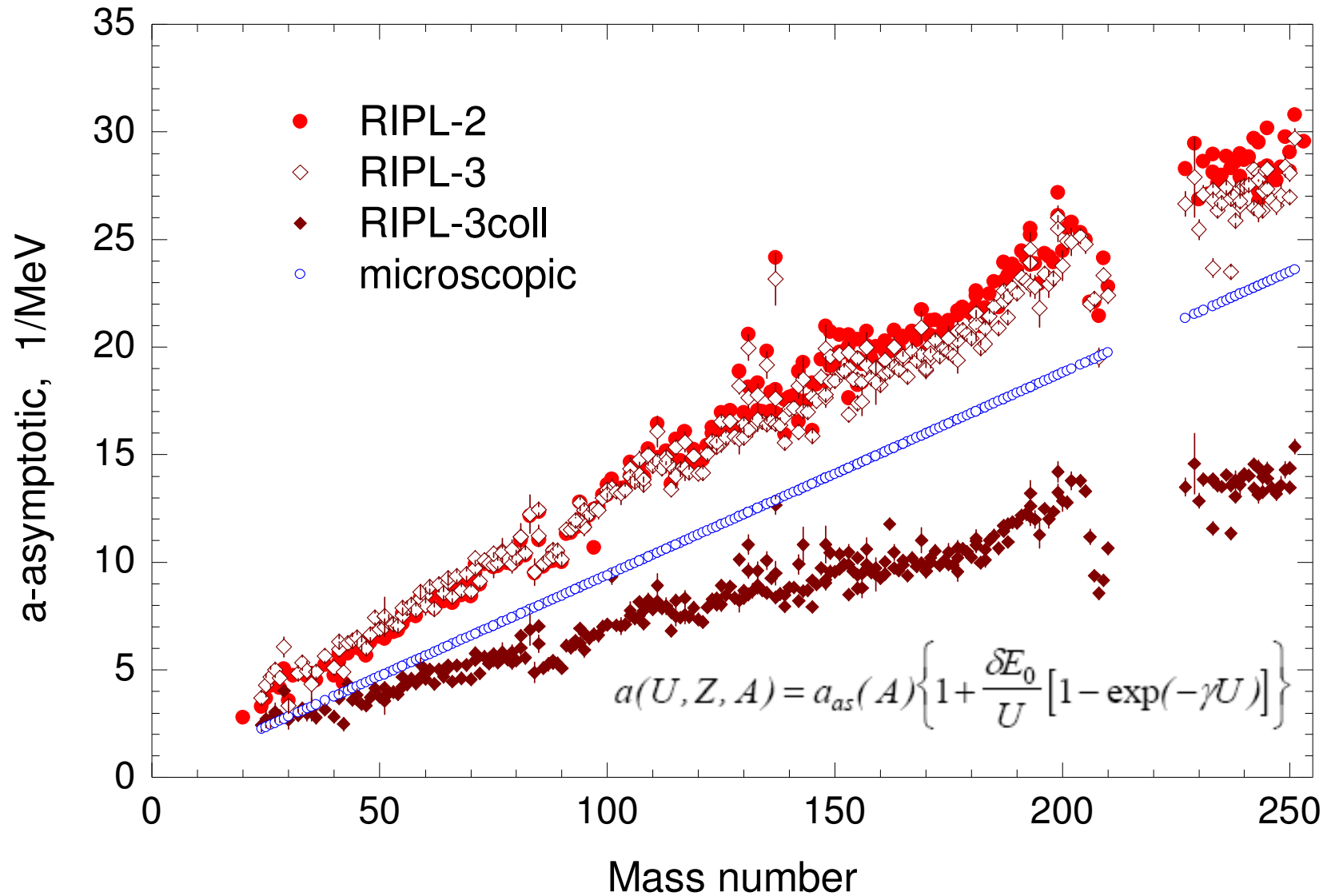
Level density parameters of the composite Gilbert-Cameron model



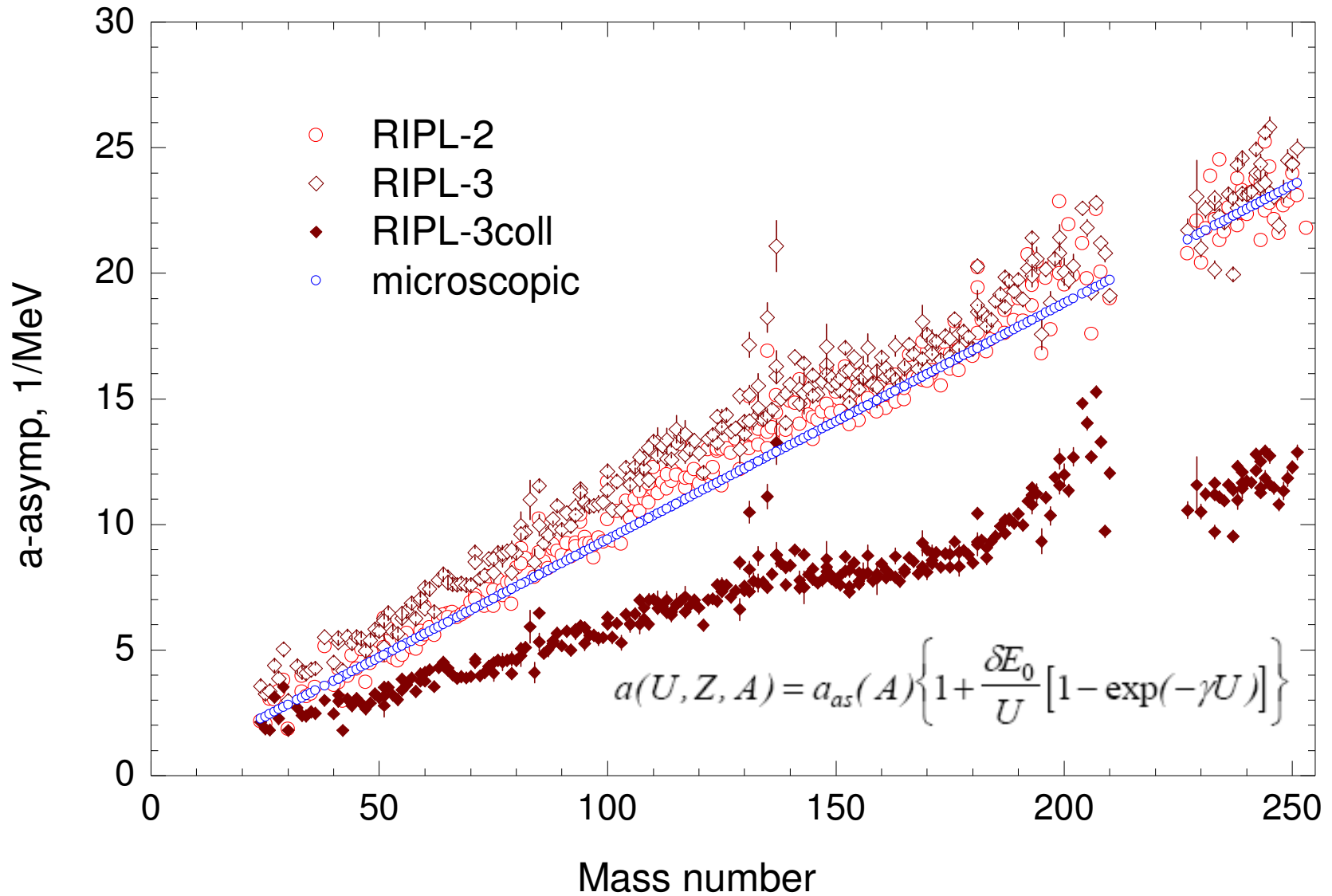


The constant temperature
model parameters
of the composite Gilbert-
Cameron model

Asymptotic values of the level density parameters



Asymptotic values of the level density parameters for the back-shifted Fermi-gas model



Asymptotic values of the level density parameters for the Generalized Superfluid Model

