Gamow-Teller nuclear resonances and neutrino capture cross-section

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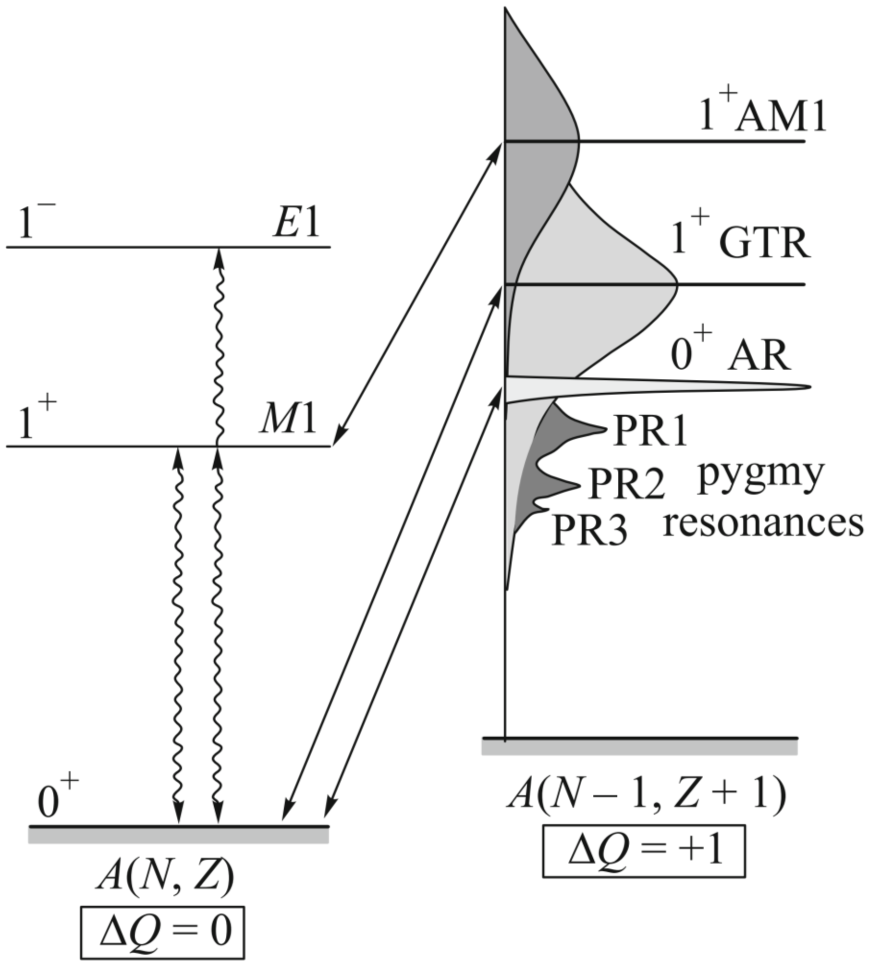
Plan

- Nuclear resonances and charge-exchange reactions
- The framework of the self-consistent theory of finite Fermi systems
- The cross-section estimation for (ν,e) reaction
- Solar neutrino capture rate
- 127Iodine detector and neutron emission

Motivation

- Neutrino capture strength function could be investigated using charge-exchange reactions.
- (p,n), (3He,t), (d,2He) reactions provide essential information about strength functions and their resonant structure.
- Giant GT-resonance and pygmy-resonances (PR1,PR2…) determine a significant part of the Strength function.
- Nuclear phenomenology could partially explain the increase in cross-sectional assessment.

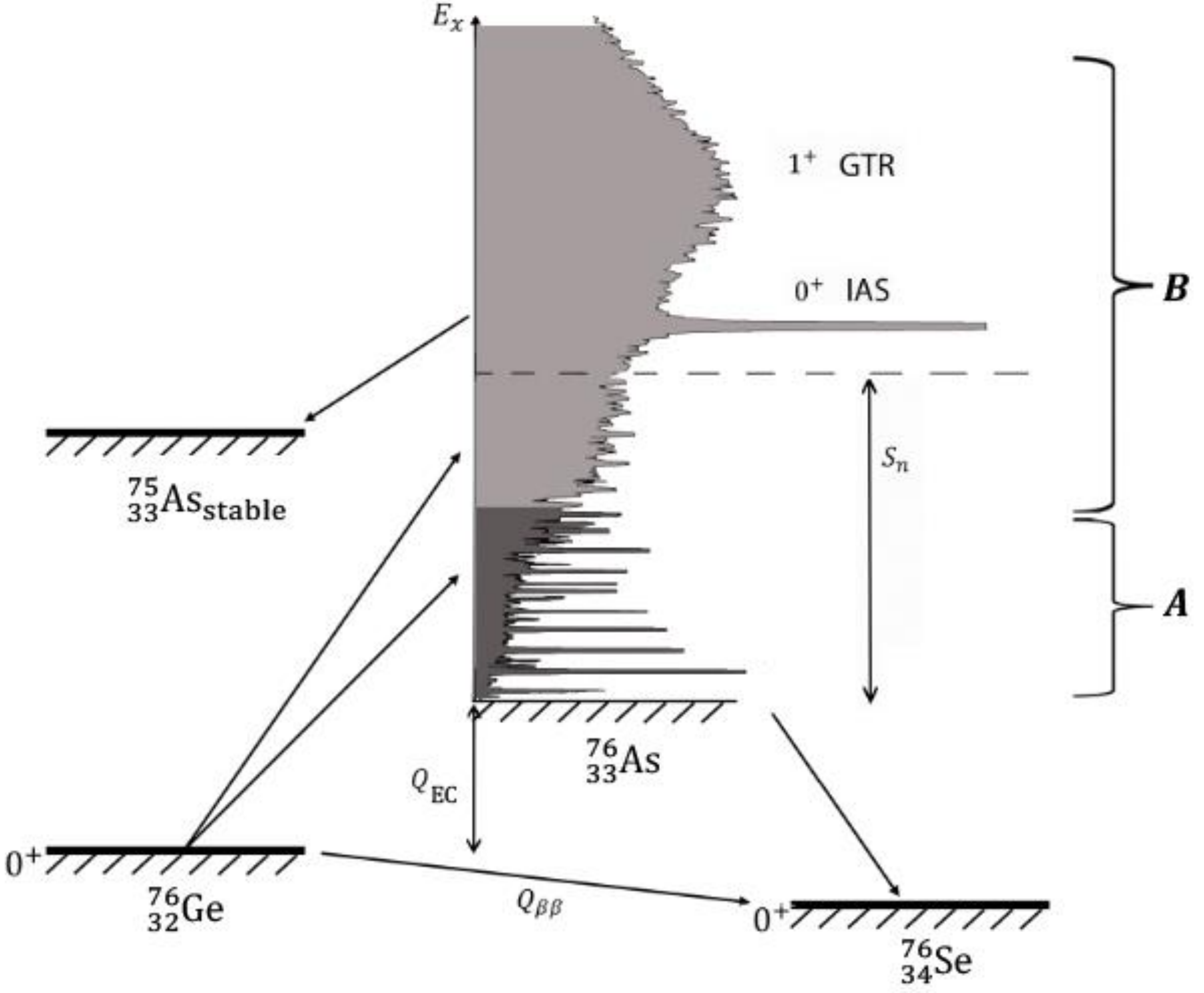
Nuclear Resonances (general view)



GTR predictions
Yu. V. Gaponov,
Yu. S. Lyutostanskii,
***JETP Lett.* 15, 120 (1972).**

PR calculations
Yu. S. Lutostansky
***JETP Lett.* 106, 7 (2017)**

Nuclear Resonances on the example for 76As



– resonances domination region

– discrete levels domination region

Neutrino Capture Cross-Section

$$\sigma_{total}(E_\nu) = \sigma_{discr}(E_\nu) + \sigma_{res}(E_\nu)$$

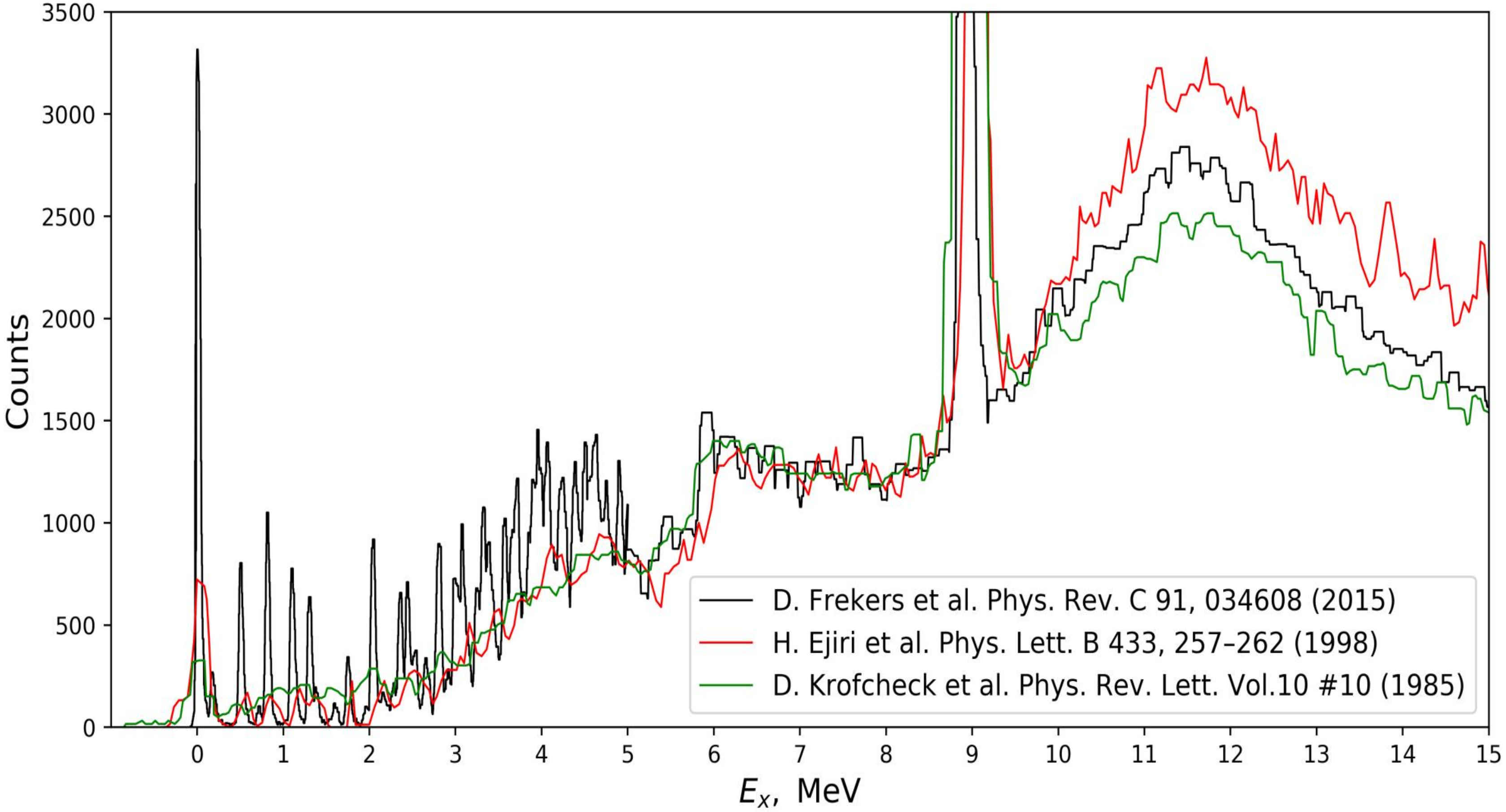
$$\sigma_{discr}(E_\nu) = \frac{1}{\pi}\sum_k G_F^2 \cos^2\theta_C\, p_e E_e F(Z,E_e)[B(F)_k + (\frac{g_A}{g_V})^2 B(GT)_k]$$

$$E_e - m_e c^2 = E_\nu - Q_{EC} - E > 0$$

$$\sigma_{res}(E_\nu) = \frac{1}{\pi}\int_{\varepsilon_{min}}^{\varepsilon_{max}} G_F^2 \cos^2\theta_C\, p_e E_e F(Z,E_e) S(E) dE$$

[A. K. Vyborov, L.V. Inzhechik, G. A. Koroteev, Yu. S. Lutostansky, V. N. Tikhonov, A. N. Fazliakhmetov. Bull. Russ. Acad. Sci. Phys. **83** (2019) 483; ЯФ **82** (2019) 397]

Charge-Exchange Reactions Comparison
$^{71}Ga(^{3}He,t)^{71}Ge$ and $^{71}Ga(p,n)^{71}Ge$



Microscopic description - 1

The Gamow–Teller resonance and other charge-exchange excitations of nuclei are described in Migdal TFFS-theory by the system of equations for the effective field:

$$V_{pn} = e_q V^{\omega}_{pn} + \sum_{p'n'} \Gamma^{\omega}_{np,\,n'p'} \rho_{p'n'} \qquad V^{h}_{pn} = \sum_{p'n'} \Gamma^{\omega}_{np,\,n'p'} \rho^{h}_{p'n'}$$

$$d^{1}_{pn} = \sum_{p'n'} \Gamma^{\xi}_{np,\,n'p'} \varphi^{1}_{p'n'} \qquad d^{2}_{pn} = \sum_{p'n'} \Gamma^{\xi}_{np,\,n'p'} \varphi^{2}_{p'n'}$$

where V_{pn} and V_{pn}^{h} are the effective fields of quasi-particles and holes, respectively;
V_{pn}^{ω} is an external charge-exchange field; d_{pn}^{1} and d_{pn}^{2} are effective vertex functions that describe change of the pairing gap Δ in an external field;
Γ^{ω} and Γ^{ξ} are the amplitudes of the effective nucleon–nucleon interaction in, the particle–hole and the particle–particle channel;
ρ, ρ^{h}, φ^{1} and φ^{2} are the corresponding transition densities.

Effects associated with change of the pairing gap in external field are negligible small, so we set $d_{pn}^{1} = d_{pn}^{2} = 0$, what is valid in our case for external fields having zero diagonal elements

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Width: $\Gamma = -2\,\mathrm{Im}\,[\sum (\varepsilon + iI)] = \Gamma = \alpha\,.\varepsilon\,|\,\varepsilon\,| + \beta\varepsilon^{3} + \gamma\,\varepsilon^{2}\,|\,\varepsilon\,| + O(\varepsilon^{4})\ldots$, **where** $\alpha \approx \varepsilon_{F}^{-1}$

$\Gamma_{i}(\omega_{i}) = 0{,}018\,\omega_{i}^{2}$ **MeV**

Microscopic description - 2

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For the GT effective nuclear field, system of equations in the energetic λ-representation has the form [FFST Migdal A. B.]:

$$\left.\begin{aligned} V_{\lambda\lambda'} &= V^{\omega}_{\lambda\lambda'} + \sum_{\lambda_1\lambda_2} \Gamma^{\omega}_{\lambda\lambda'\lambda_1\lambda_2} A_{\lambda_1\lambda_2} V_{\lambda_2\lambda_1} + \sum_{\nu_1\nu_2} \Gamma^{\omega}_{\lambda\lambda'\nu_1\nu_2} A_{\nu_1\nu_2} V_{\nu_2\nu_1}; \\ V_{\nu\nu'} &= \sum_{\lambda_1\lambda_2} \Gamma^{\omega}_{\nu\nu'\lambda_1\lambda_2} A_{\lambda_1\lambda_2} V_{\lambda_2\lambda_1} + \sum_{\nu_1\nu_2} \Gamma^{\omega}_{\nu\nu'\nu_1\nu_2} A_{\nu_1\nu_2} V_{\nu_2\nu_1}; \\ V^{\omega} &= e_q \boldsymbol{\sigma\tau}^+; \quad A^{(p\bar{n})}_{\lambda\lambda'} = \frac{n^n_\lambda (1 - n^p_{\lambda'})}{\varepsilon^n_\lambda - \varepsilon^p_{\lambda'} + \omega}; \quad A^{(n\bar{p})}_{\lambda\lambda'} = \frac{n^p_\lambda (1 - n^n_{\lambda'})}{\varepsilon^p_\lambda - \varepsilon^n_{\lambda'} - \omega}. \end{aligned}\right\}$$

G -T selection rules:

Δ*j* =0;±1

Δ*j* =+1: *j=l+1/2 → j =l–1/2*

Δ*j* =0: *j=l±1/2 → j=l±1/2*

Δ*j* = –1: *j=l–1/2 → j=l+1/2*

j =l–1/2→ j =l–1/2

where n_λ and ε_λ are, respectively, the occupation numbers and energies of states λ.

Local nucleon–nucleon δ-interaction Γ^ω in the Landau-Migdal form used:

$$\Gamma^{\omega} = C_0 (f_0' + g_0' \sigma_1\sigma_2)\, \tau_1\tau_2\, \delta(r_1 - r_2)$$

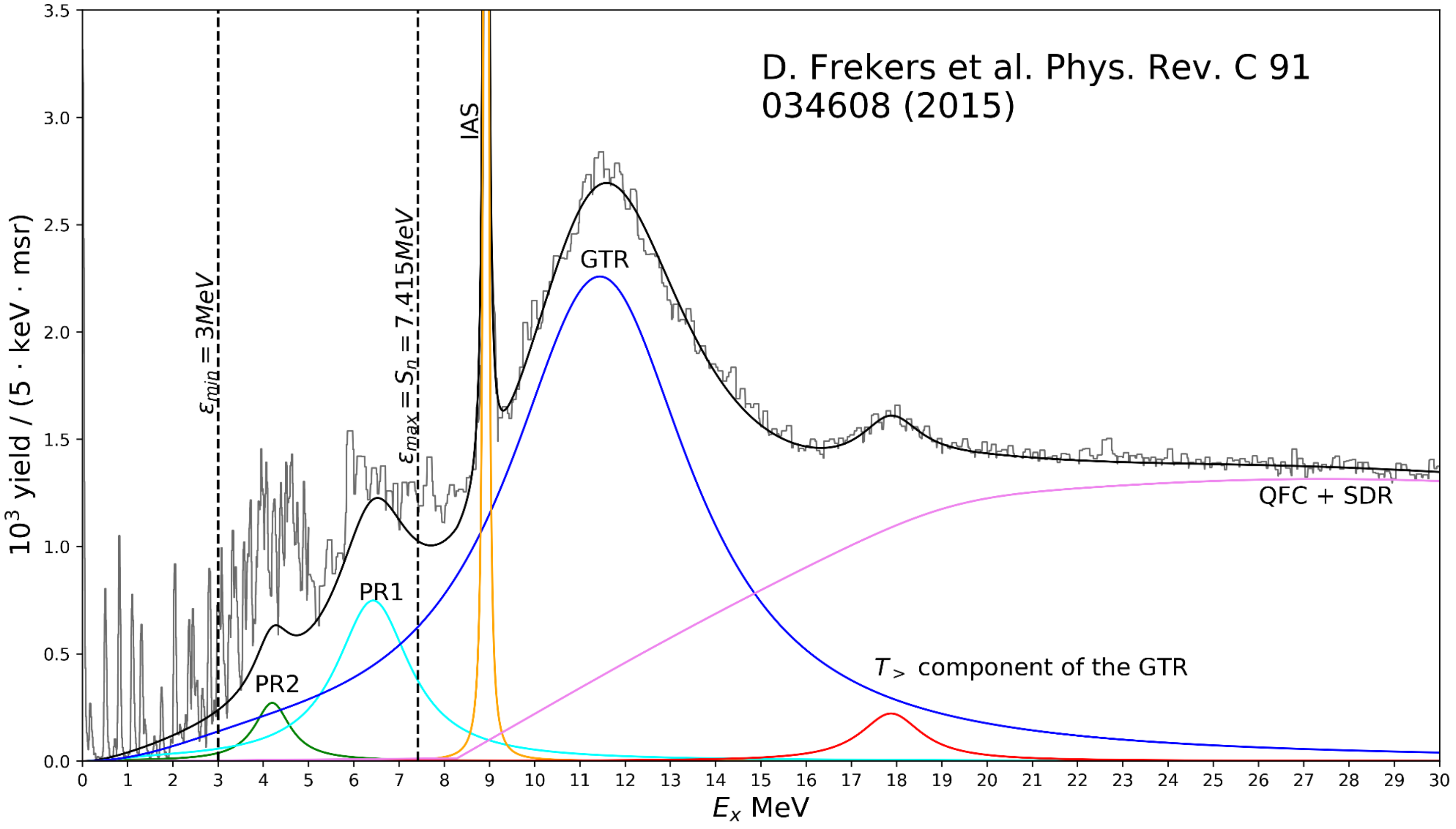
where coupling constants of: f_0'=1.35 – isospin-isospin and g_0'=1.22 – spin-isospin quasi-particle interaction with L = 0.

Matrix elements M_{GT} : $M^2_{GT} = \sum_{\lambda_1\lambda_2} \chi_{\lambda_1\lambda_2} A_{\lambda_1\lambda_2} V^{\varpi}_{\lambda_1\lambda_2}$ where $\chi_{\lambda\nu}$ – mathematical deductions

GT - values are normalized in FFST: $\sum_i M_i^2 = e_q^2 3(N - Z)$

Yu. S. Lutostansky and V.N.Tikhonov, Physics of Atomic Nuclei, 2016, Vol. 79, No. 6

Experimental data and Fit



Fitting Parameters

$$S_i(E) = M_i^2 \cdot \frac{\Gamma_i(1-\exp(-(E/\Gamma_i)^2))}{(E-w_i)^2+\Gamma_i^2}$$

- shape form for all the resonances. 3 free parameters: the centroid energies, the widths, and the amplitudes.

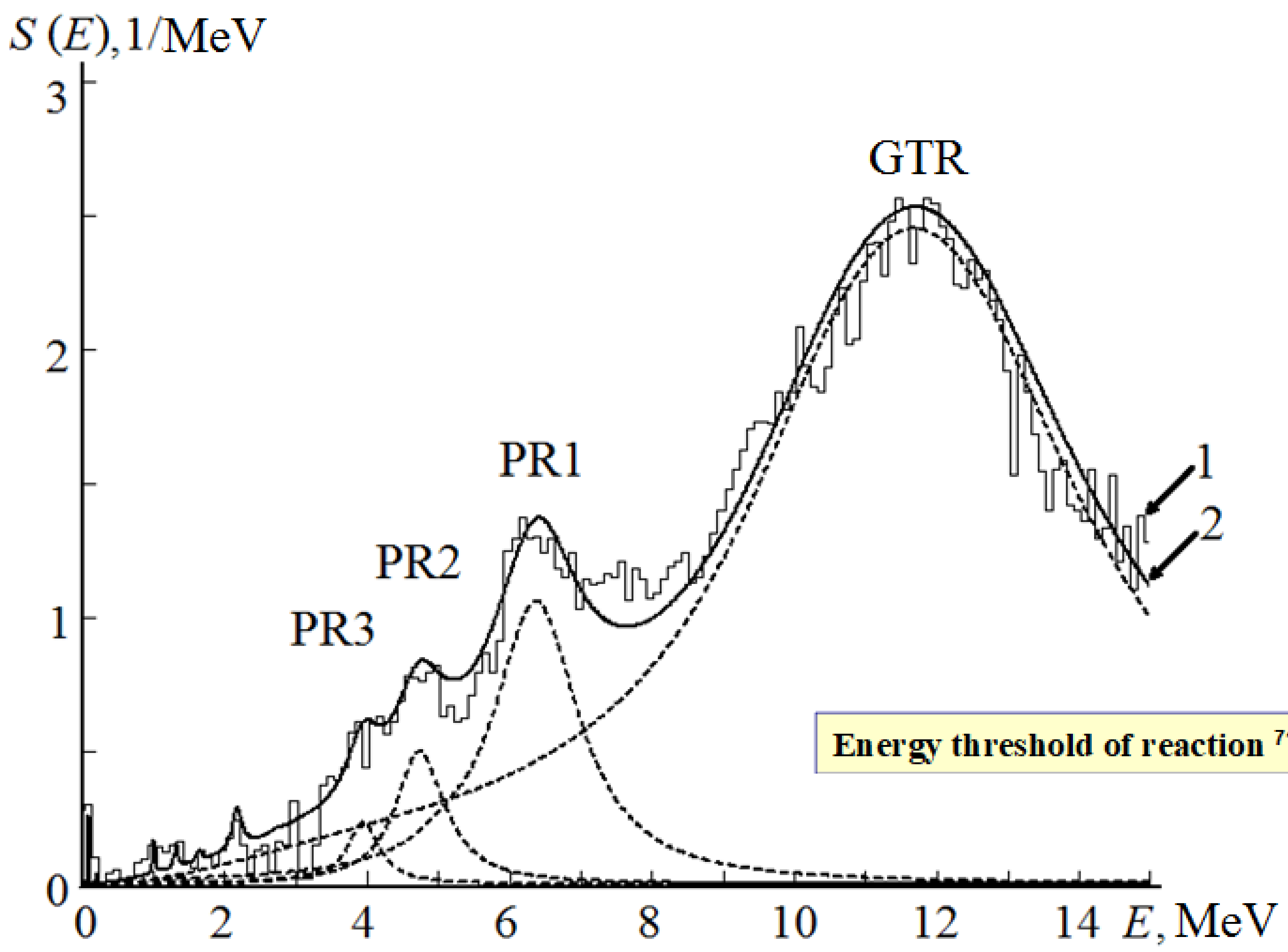
$$\frac{d^2\sigma}{dEd\Omega} = N_0 \frac{1-\exp[(E_t-E_0)/T]}{1+[(E_t-E_{QF})/W^2]}$$

- QFC background shape *J. Jänecke et al. Phys. Rev. C* ***48****, 2828 (1993)*

Only N_0 and E_{QF} are used as free parameters.

Data for the fit is taken from **D. Frekers et al. Phys. Rev. C 91, 034608 (2015)**

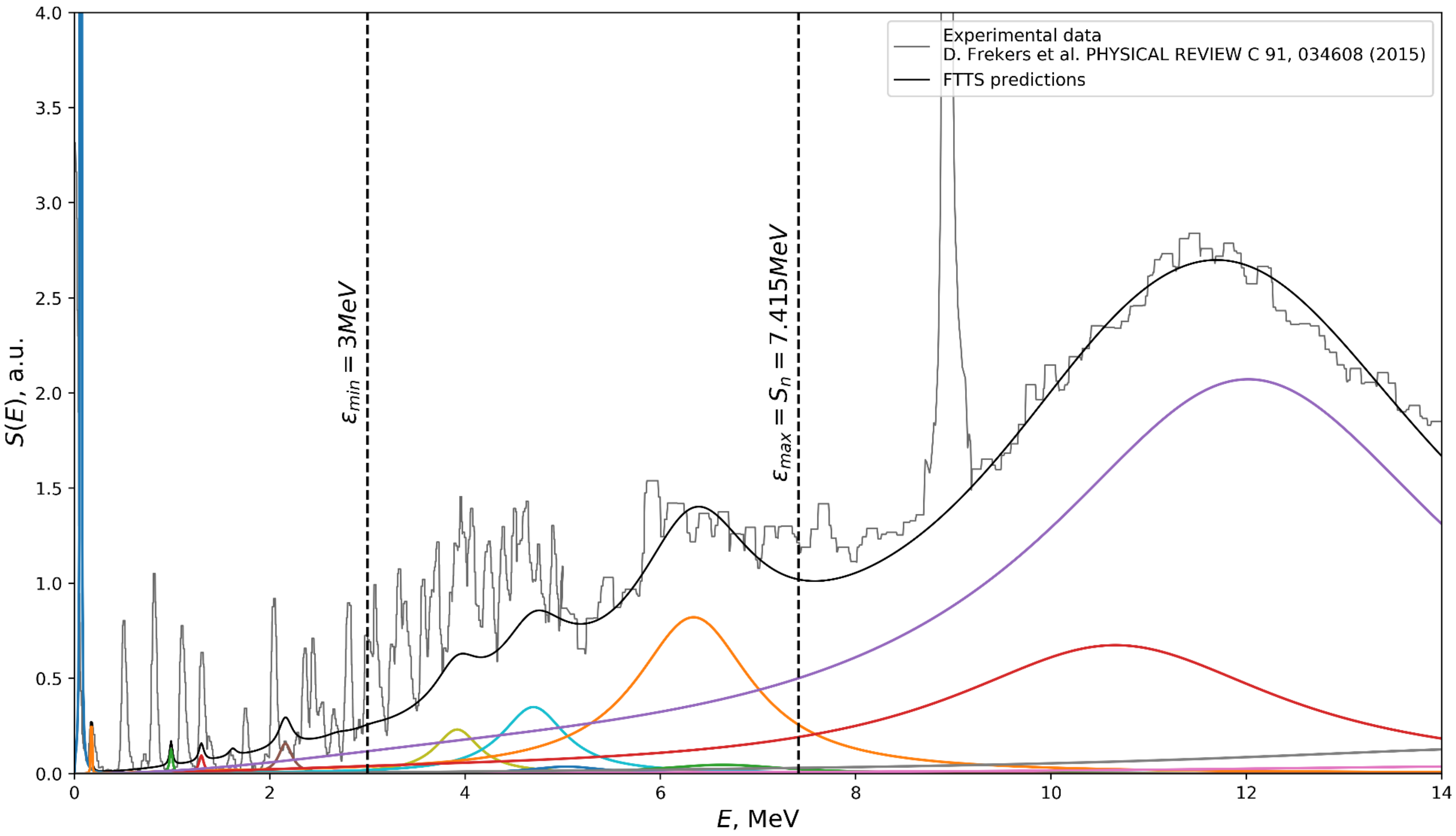
Charge-Exchange Strength Function of Reaction $^{71}Ga(p,n)^{71}Ge$



Energy threshold of reaction $^{71}Ga(\nu,e)^{71}Ge$ = 232.64 keV

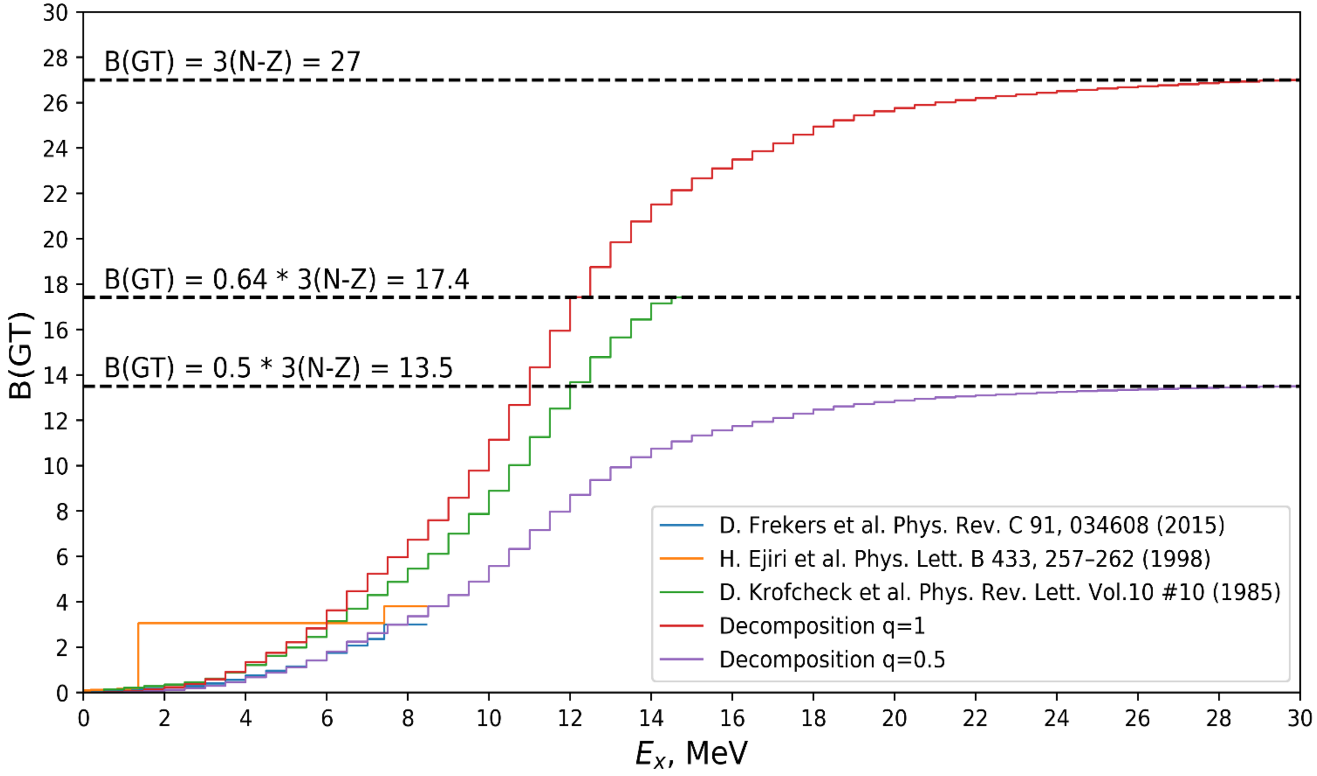
1 – Bar chart - experiment D. Krofcheck, *et. al.*, Phys. Rev. Lett. 1985. v. 59. p.1051;
2 – Line – numerical calculation by TFFS with e_q=0.9.
GTR – Gamow-Teller resonance; PR1, PR2, PR3 – pygmy resonances.

TFFS prediction for GT-resonances spectrum vs. experimental strength function



Normalization and Quenching effect

$$\sum_i M_i^2 = \sum_k B(GT)_k + \int_{\Delta_{min}=0}^{\Delta_{max}=30\ MeV} S(E)dE = 3 \cdot (N-Z) \cdot q_{exp} = 27 \cdot q_{exp}$$



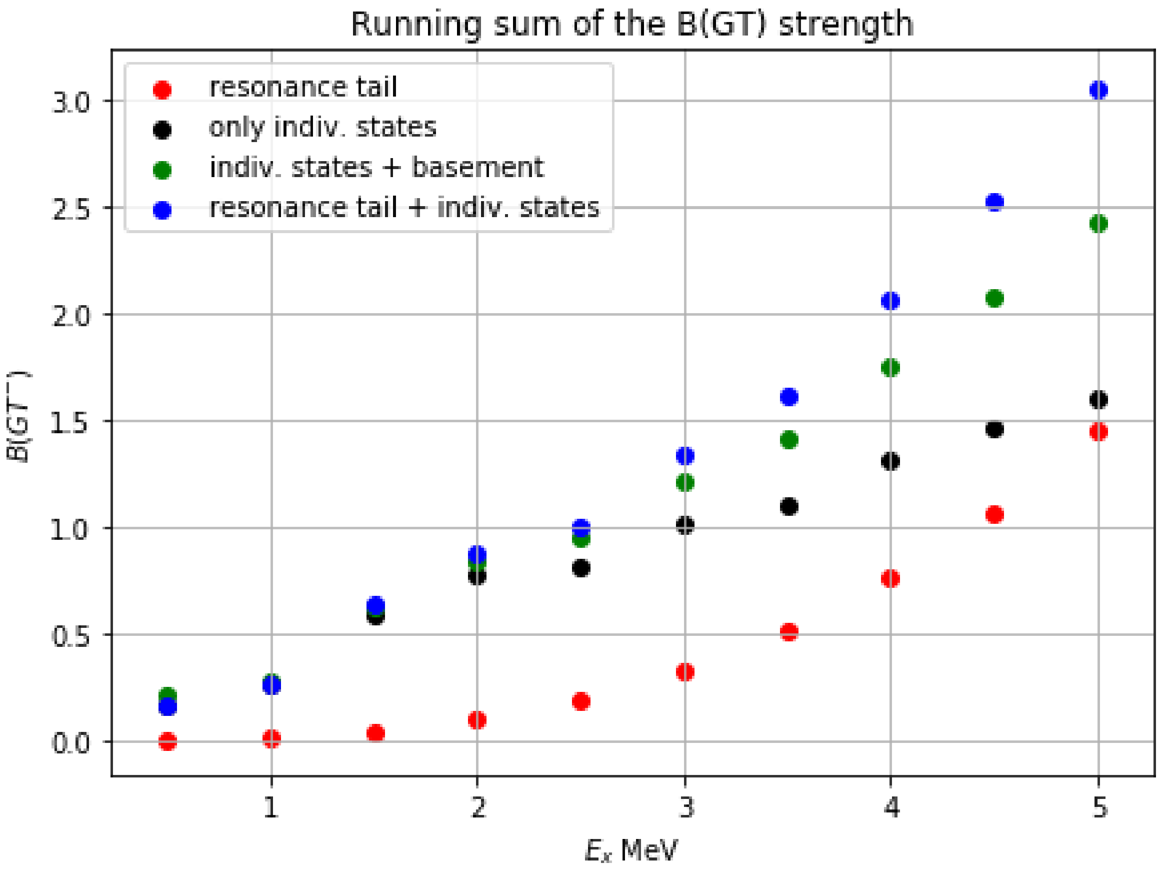
NORMALISATION

"*Quenching*" effect (Losing of sum rule in beta-strength) is the main ~ 50 - 70%

$$q_{exp}^{max} = 1$$

$$q_{exp} \approx 0.5$$

Alternative version of the basement for

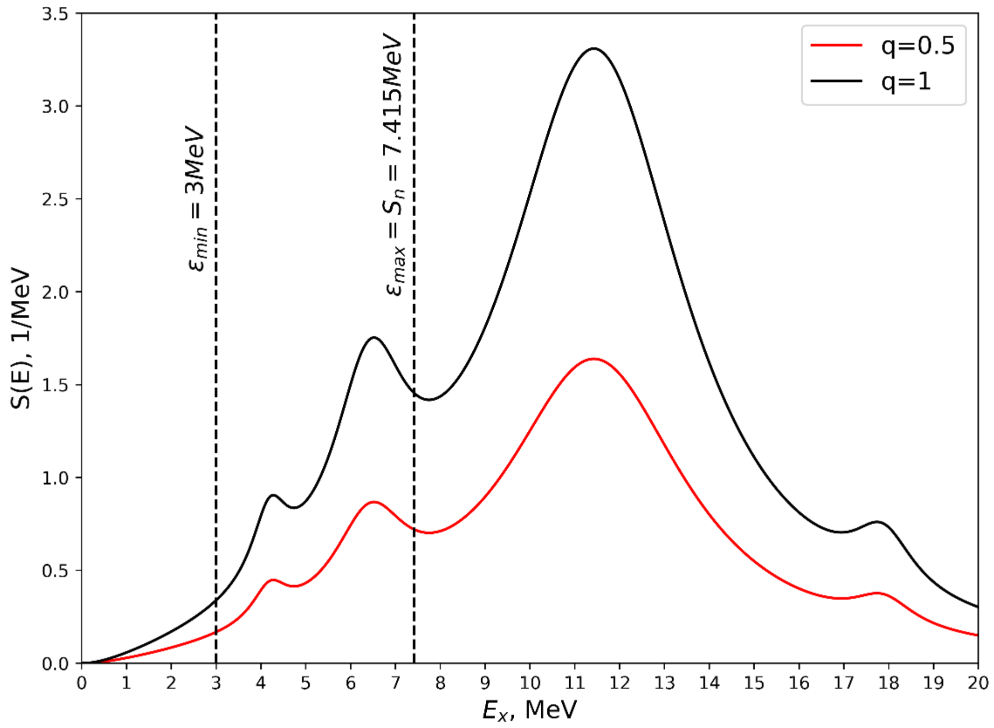


- **Black** and **Green** points as in **the D. Frekers et al. Phys. Rev. C 91, 034608 (2015)**
- **Red** and **Blue** points corresponds to the our B(GT) extraction from resonant part of the experimental strength function and their sum with individual states.
- Here we use just the most “conservative” estimation, only from GTR and PR1, PR2 resonances.

Solar neutrino capture rate

$$R = \int_0^{E_{max}=18.79\,MeV} \rho_{solar}(E_\nu)\sigma_{solar}(E_\nu)dE_\nu \qquad R_{total} = R_{discr} + R_{res}$$

$$\sigma_{res}(E_\nu) = \frac{1}{\pi}\int_{\varepsilon_{min}}^{\varepsilon_{max}} G_F^2 \cos^2\theta_C\, p_e E_e F(Z, E_e) S(E) dE$$

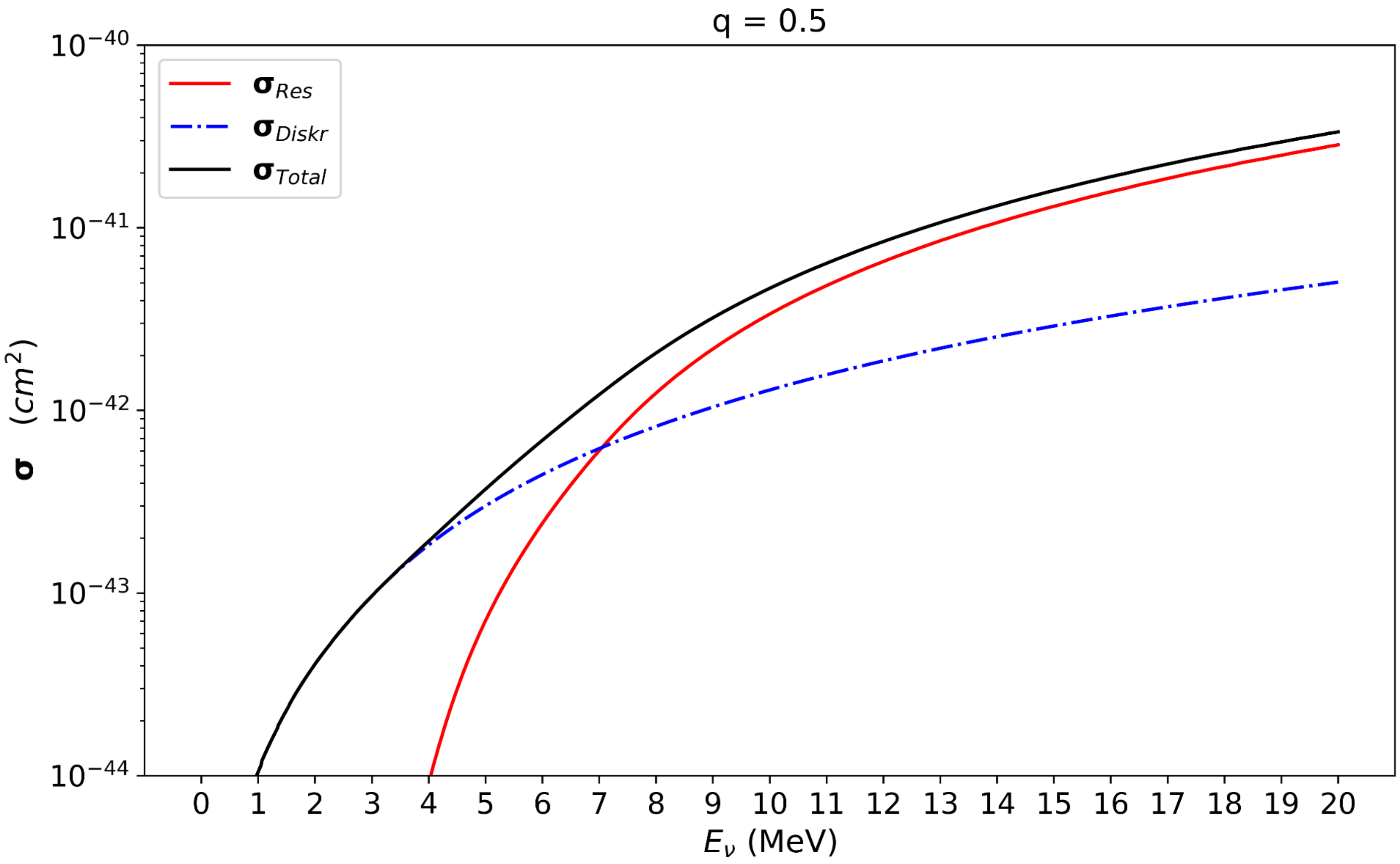


Neutron emission (S_n) role was discused by

A. Fazliakhmetov

https://indico.tlabs.ac.za/event/85/contributions/1552/

Neutrino capture cross-section for 71Ga



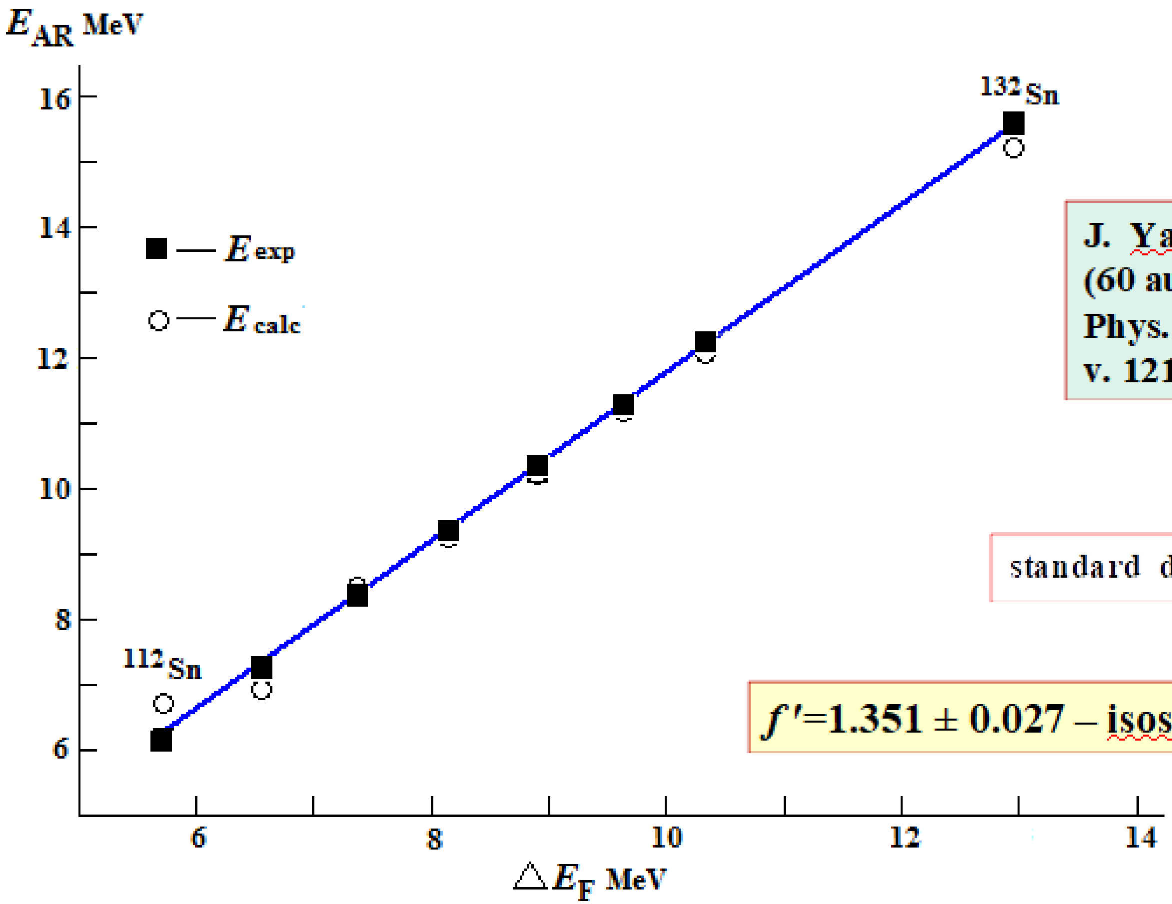
Solar neutrino capture rate for 71Ga

Capture rate [SNU]	D. Frekers et al. Phys. Rev. C 91, 034608 (2015)	Calculation q=1	Calculation q=0.5
R_{diskr}	115.9	119.5	119.5
R_{3-S_n}	6.5	14.2	7.0
R_{total}	122.4	133.7	126.5

Solar component	Total capture rate [SNU]		
	D. Frekers et al. Phys. Rev. C 91, 034608 (2015)	Calculation q=1	Calculation q=0.5
pp	69.9	72.0	72.0
pep	3.4	3.5	3.5
^7Be	36.7	38.1	38.1
^8B	10.1	17.7	10.6
$\left\{ ^{13}N, ^{15}O, ^{17}F \right.$	2.2	2.3	2.3
R_{total}	122.4	133.7	126.5

Gamow Teller and Analog resonances

Sn – Isotopes Analog Resonance – AR = IAS ENERGIES



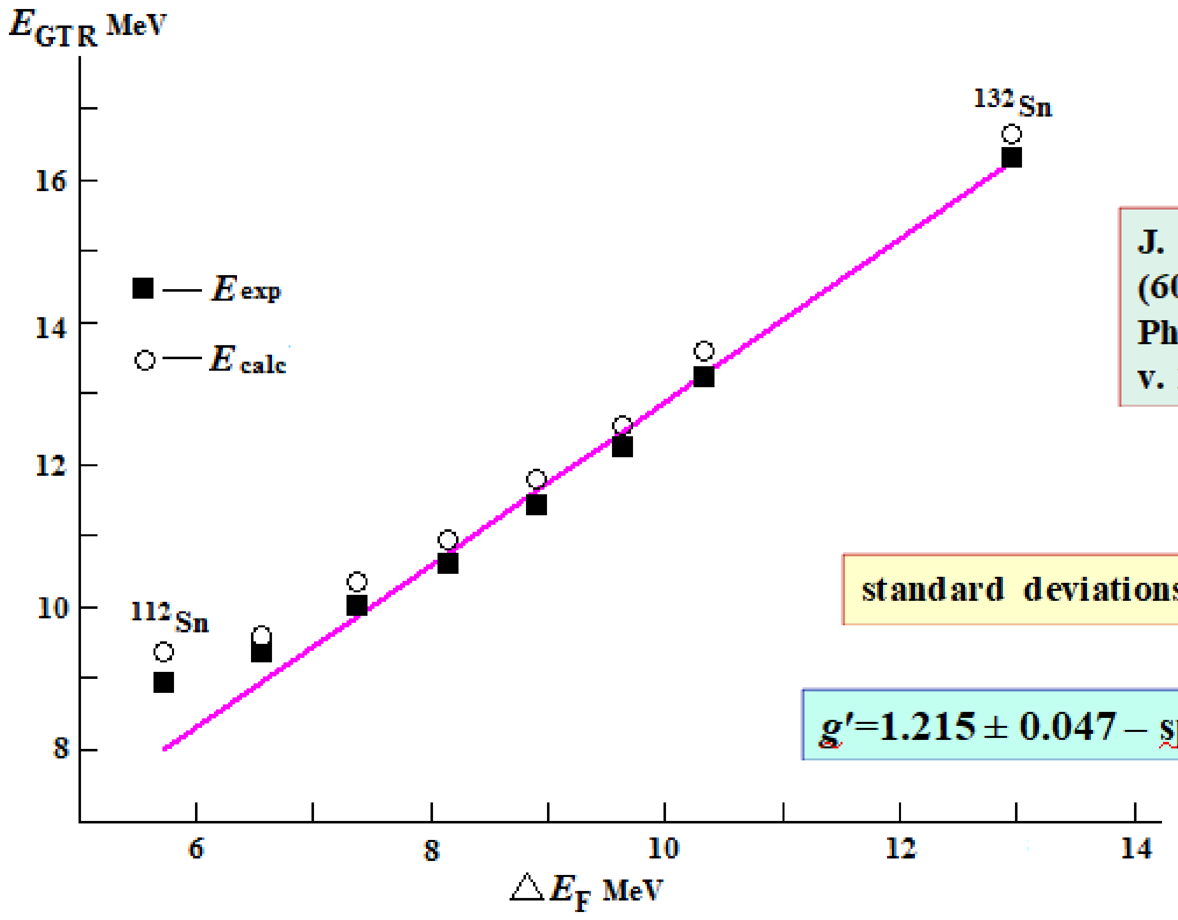
J. Yasuda, *et al.*
(60 authors)
Phys. Rev. Lett.
v. 121, 132501 (2018).

standard deviations $\delta(\Delta E_{IAS}) < 170$ keV

f'=1.351 ± 0.027 – isospin-isospin parameter

$$E_{AR} = f' \, \Delta E_F \qquad \Delta E_F = E_F(n) - E_F(p)$$

Sn – Isotopes Gamow-Teller Resonance – GTR Energies



J. Yasuda, *et al.*
(60 authors)
Phys. Rev. Lett.
v. 121, 132501 (2018).

standard deviations $\delta(\Delta E_{GTR}) < 350$ keV

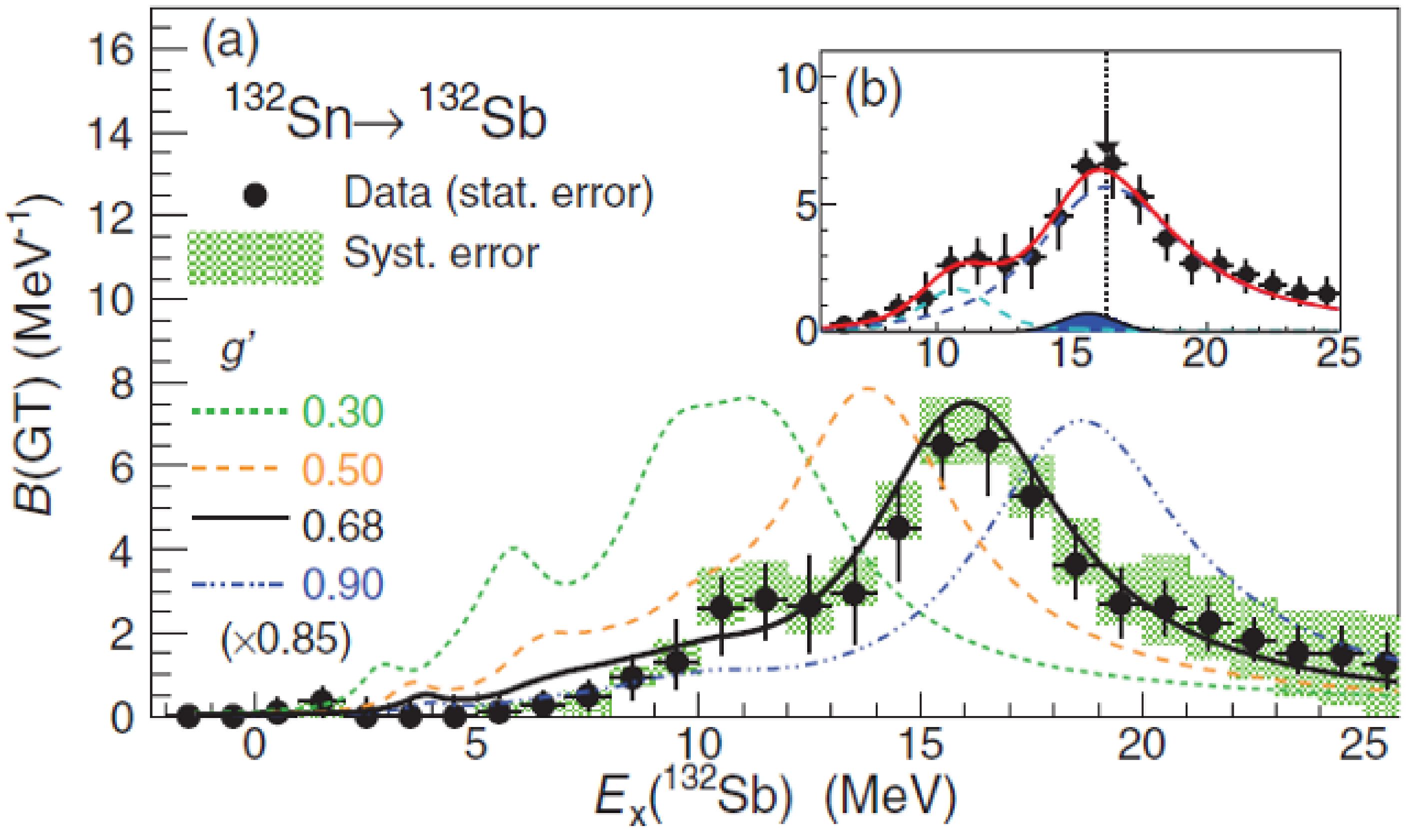
$g' = 1.215 \pm 0.047$ – spin-isospin parameter

$E_{GTR} = g'(1+?)\,\Delta E_F$ $\quad \Delta E_F = E_F(n) - E_F(p)$

Charge-Exchange Strength Function of Reaction $^{132}Sn(p,n)^{132}Sb$

Extraction of the Landau-Migdal Parameter from the Gamow-Teller Giant Resonance in ^{132}Sn

J. Yasuda *et al.* (60 authors) Phys. Rev. Lett. v. 121, 132501 (2018).



Experimental data on the reaction $^{132}Sn(p,n)^{132}Sb$ were compared with theoretical RPA calculations with different values of the parameter *g'* and than fitting of this parameter

E_{GTR} and E_{AR} TFFS CALCULATIONS

Nucleus in/out	$\frac{N-Z}{A}$	E_{AR}, MeV		E_{GTR}, MeV		E_{GTR} - E_{AR}, MeV		
		calc.	exp.	calc.	exp.	calc.	(1)	exp.
^{112}Sn / ^{112}Sb	0.107	6.69	6.16	9.38	8.94 ± 0.25	2.69	2.89	2.78 ± 0.3
^{114}Sn / ^{114}Sb	0.123	6.92	7.28	9.60	9.39 ± 0.25	2.68	2.17	2.11 ± 0.3
^{116}Sn / ^{116}Sb	0.138	8.47	8.36	10.36	10.04 ± 0.25	1.89	1.75	1.68 ± 0.3
^{117}Sn / ^{117}Sb	0.145	11.38	11.27	12.91	12.87 ± 0.25	1.53	1.63	1.60 ± 0.3
^{118}Sn / ^{118}Sb	0.153	9.23	9.33	10.93	10.61 ± 0.25	1.70	1.52	1.28 ± 0.3
^{119}Sn / ^{119}Sb	0.160	12.48	12.36	13.77	13.71 ± 0.25	1.29	1.41	1.35 ± 0.3
^{120}Sn / ^{120}Sb	0.167	10.20	10.24	11.78	11.45 ± 0.25	1.58	1.36	1.21 ± 0.3
^{122}Sn / ^{122}Sb	0.180	11.17	11.24	12.54	12.25 ± 0.25	1.37	1.22	1.01 ± 0.3
^{124}Sn / ^{124}Sb	0.194	12.05	12.19	13.59	13.25 ± 0.25	1.54	1.14	1.06 ± 0.3
^{132}Sn / ^{132}Sb	0.242	15.21	15.6	16.63	16.3 ± 0.4	1.42	1.02	0.7 ± 0.4
$\langle E_{exp} - E_{calc} \rangle$, MeV ‹standard deviations›		0.24		0.35		0.39	0.20	

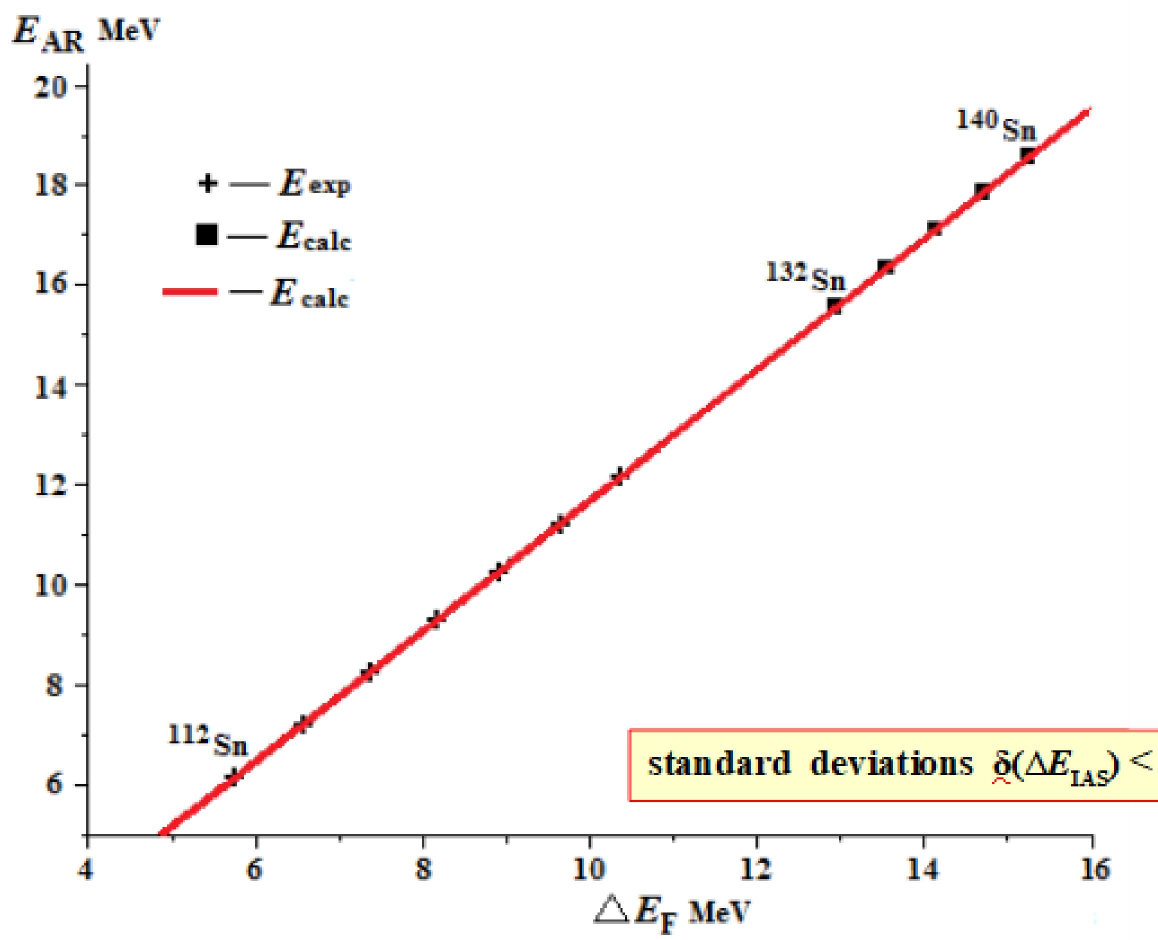
$$E_{GTR} - E_{AR} = (g'_0 - f'_0)\Delta E + b\frac{1 + b g'_0}{g'_0}\frac{E_{ls}^2}{\Delta E}[1 + c(A)x^2]^{-1}; \quad b = \frac{2}{3}[1 - (2A)^{-1/3}]; \quad c(A) \approx 0.8A^{-1/3} \text{ MeV} \quad \textbf{(1)}$$

Table. Energies (in MeV) of the analog – E_{AR}, Gamow-Teller – E_{GTR}, and three pigmy resonances – E_{PR} according to the TFFS microscopic calculations and experimental data for tin isotopes from [6], as well as the standard deviations $\langle E_{exp} - E_{calc} \rangle$ of the calculations and experimental data.

Nucleus initial/final	E_{AR}		E_{GTR}		E_{PR1}		E_{PR2}		E_{PR3}	
	exp. ± 0.03	calc.	exp. ± 0.25	calc.	exp. ± 0.25	calc.	exp. ± 0.20	calc	exp. ± 0.20	calc.
^{112}Sn / ^{112}Sb	6.16	6.69	8.94	9.38	4.08	4.70	2.49	3.00	1.33	1.52
^{114}Sn / ^{114}Sb	7.28	6.92	9.39	9.60	4.55	4.97	2.95	2.65	1.88	1.60
^{116}Sn / ^{116}Sb	8.36	8.47	10.04	10.36	5.04	5.23	3.18	2.68	1.84	1.75
^{117}Sn / ^{117}Sb	11.27	11.38	12.87	12.91	7.64	7.54	5.45	5.21	3.87	3.71
^{118}Sn / ^{118}Sb	9.33	9.23	10.61	10.93	5.38	5.54	3.17	3.08	1.47	1.55
^{119}Sn / ^{119}Sb	12.36	12.48	13.71	13.77	8.09	8.27	5.49	5.57	3.63	4.07
^{120}Sn / ^{120}Sb	10.24	10.20	11.45	11.78	5.82	6.24	3.18	3.47	1.38	0.98
^{122}Sn / ^{122}Sb	11.24	11.17	12.25	12.54	6.65	6.76	3.37	3.91	1.45	1.55
^{124}Sn / ^{124}Sb	12.19	12.05	13.25	13.59	7.13	7.16	3.44	3.06	1.50	2.17
$\langle E_{exp} - E_{calc} \rangle$	0.17		0.29		0.31		0.36		0.33	

[6]. K. Pham, J. Jänecke, D. A. Roberts, M.N. Harakeh, G.P.A. Berg, S. Chang, J. Liu, et al. Fragmentation and splitting of Gamov-Teller resonances in Sn(^{3}He,*t*)Sb charge-exchange reactions, $A = 112$-124. Phys. Rev. C 51, 526 (1995).

Sn – Isotopes Analog Resonance – AR = IAS ENERGIES



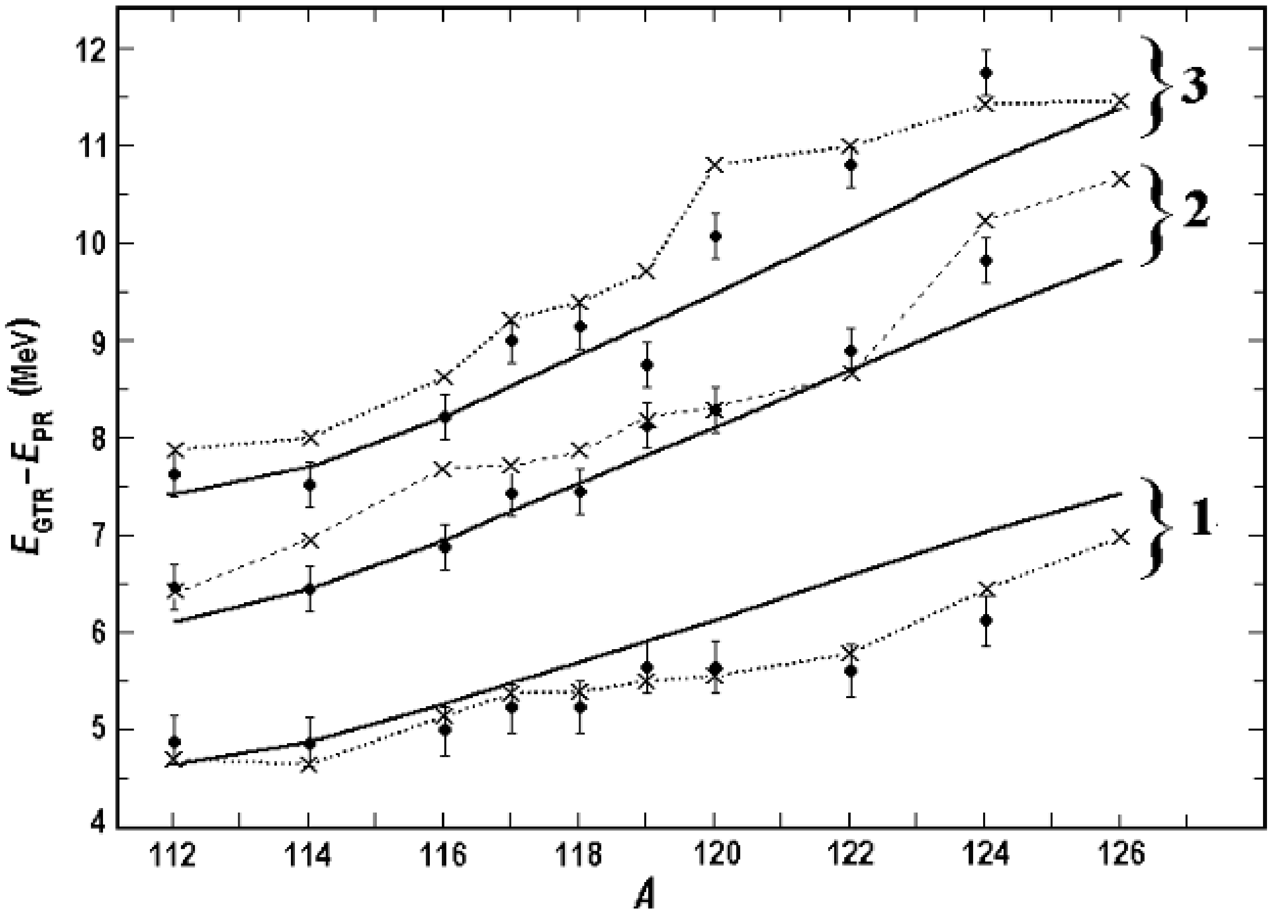
standard deviations $\delta(\Delta E_{IAS}) < 30$ keV

$E_{AR} = f'\ \Delta E_F \qquad \Delta E_F = E_F(n) - E_F(p) = \frac{4}{3} E_F \frac{N-Z}{A}$

$f' = 1.35$ – isospin-isospin parameter

$\Gamma^{\omega} = C_0\,(f' + g'\,\sigma_1\sigma_2)\,\tau_1\tau_2\,\delta(r_1 - r_2)$; Linear dependence E_{AR} from f'

Energies E(GTR) – E(PR) for Sn isotopes



Difference between the energies of the GTR and pygmy resonances (PR) lying below it for Sn isotopes from the mass number A according to (•) – experimental data [6], (×) connected by the dashed line – TFFS numerical calculations; lines – model formula calculations. Digits 1, 2 and 3 mark groups of excitations belonging to pygmy resonances: PR1 – 1, PR2 – 2 and PR3 – 3.

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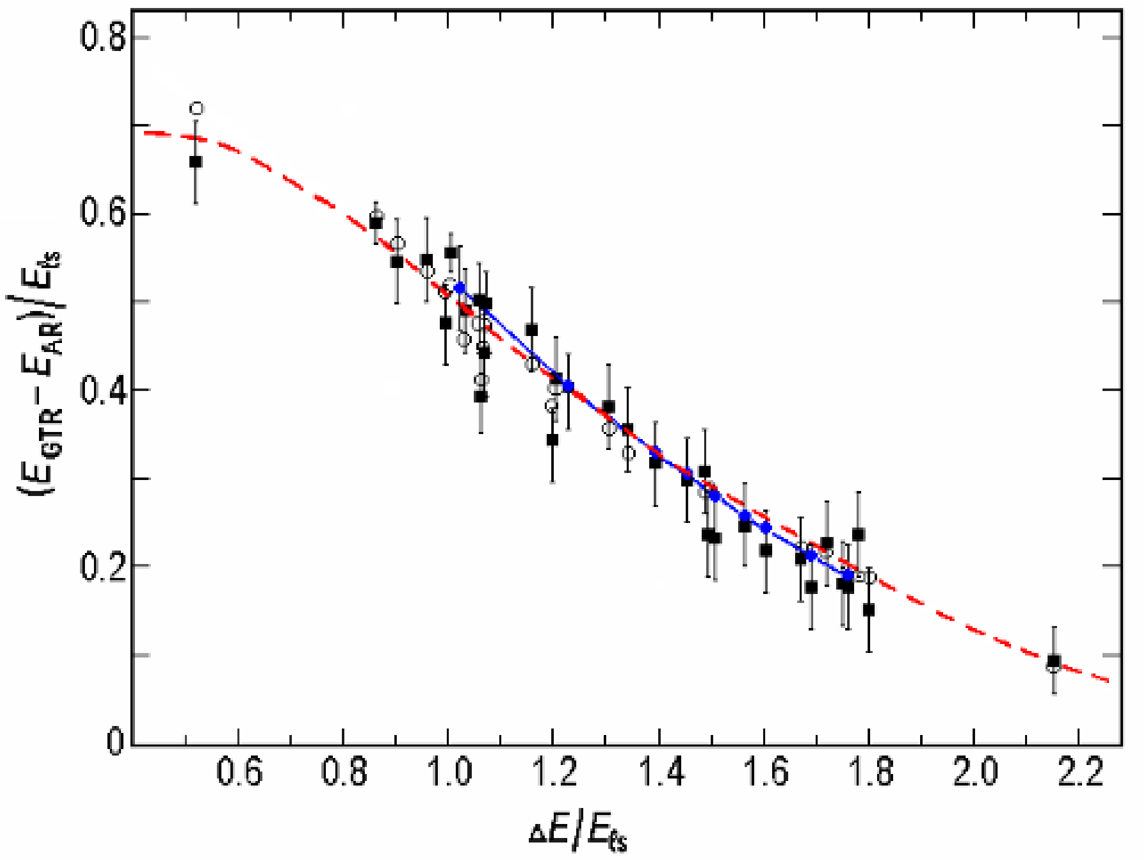
[6]. K. Pham, J. Jänecke, et al. Phys. Rev. C 51, 526 (1995).

$E_{GTR} - E_{AR}$ MODEL DESCRIPTION - 1



Mat. model developed for the approximate solutions of equations of the FFST theory by the quasi-classical method.

2 new parameters:

$$\Delta E = E_F(n) - E_F(p) = $$

$$= \frac{4}{3} E_F \frac{N-Z}{A}$$

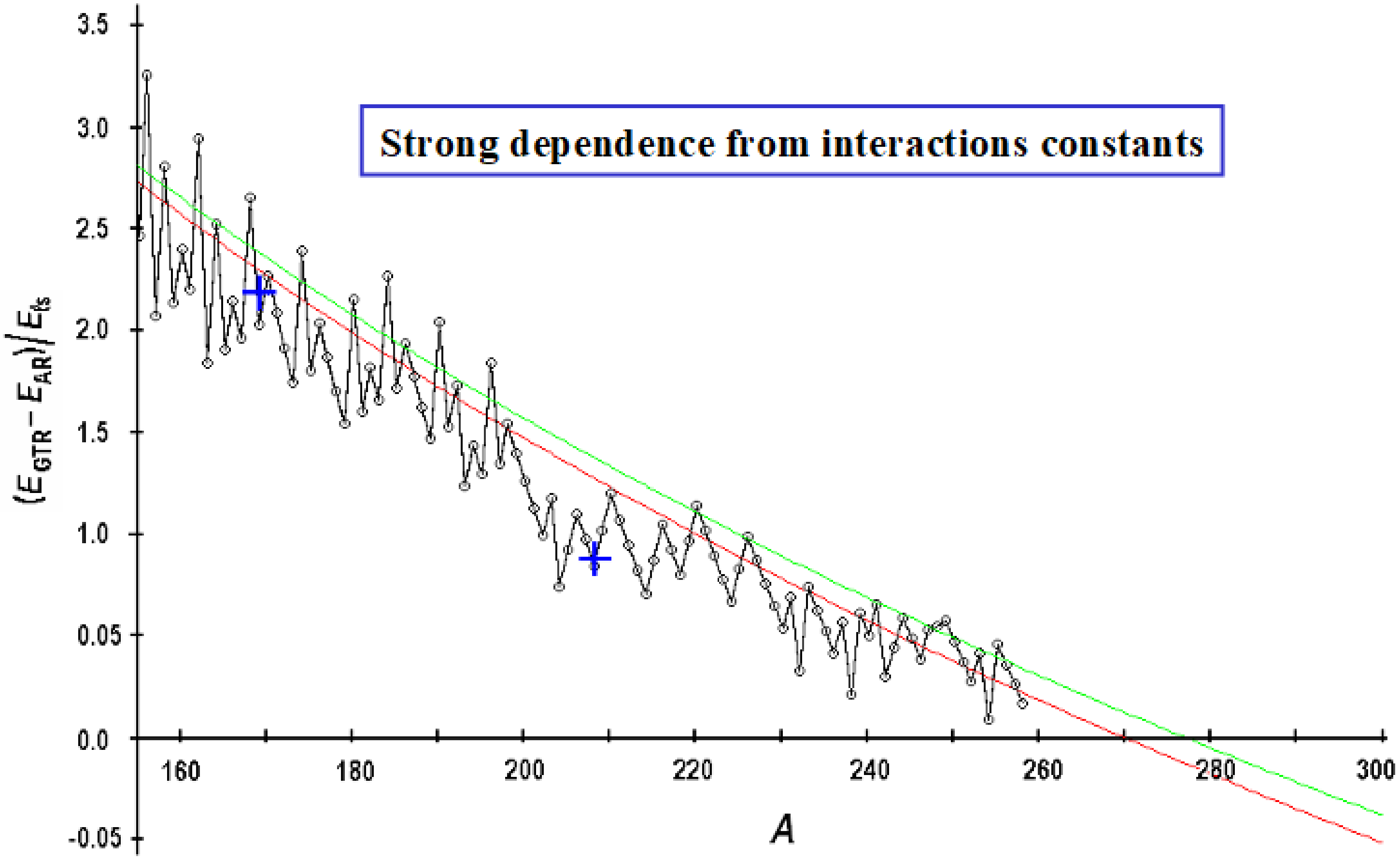
E_{ls} – average energy of the spin–orbit splitting

Degeneration of GTR and AR = Wigner's SU(4) super-symmetry restoration in the heavy nuclei

Calculated TFFS (circles – ○) and experimental (■) dependencies of the relative energy $y(x) = \Delta(E_{GTR}\text{-}E_{AR})/E_{ls}$ from the dimensionless value $x=\Delta E/E_{ls}$. Blue circles (•) connected by line – calculated values for Sn isotopes. Red line – calculations with $E_{ls}(N) = 20N^{-1/3} + 1.25$ (MeV).

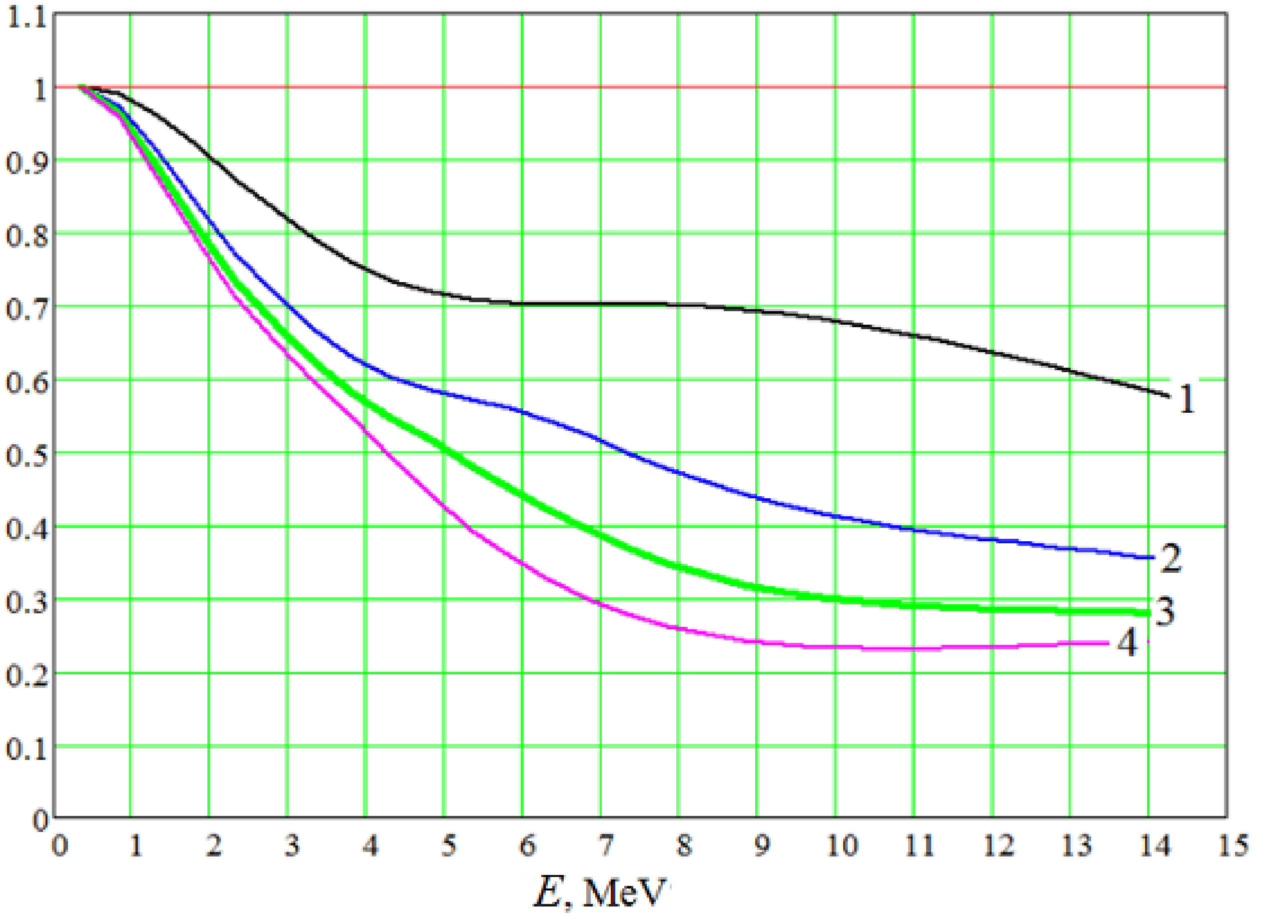
$$y = \frac{E_{GTR} - E_{AR}}{E_{ls}} = (g_0' - f_0')x + b\frac{1+b\,g_0'}{g_0'\,x}[1+c(A)x^2]^{-1}; \quad x = \Delta E / E_{ls}; \quad b = \frac{2}{3}[1-(2A)^{-1/3}]; \quad c(A) \approx 0.8A^{-1/3}$$

$E_{GTR} – E_{AR}$ MODEL DESCRIPTION - 2



+ Exp. Data. circles – ○: calc. for Nucl. on Exp. Line of beta-stability up to ^{258}Fm. Red line: calculated values for nuclei on the line of beta-stability with $E_{ls}(N) = 20N^{-1/3} + 1.25$ (MeV), $Z_\beta(A)=A/(2+0{,}015A^{2/3})$, and with $f_0^{/} = 1.35$, $g_0^{/} = 1.22$ up to $A_{max} = 270$. Green line: the same with $f_0^{/} = 1.345$, $g_0^{/} = 1.22$ up to $A_{max} = 280$.

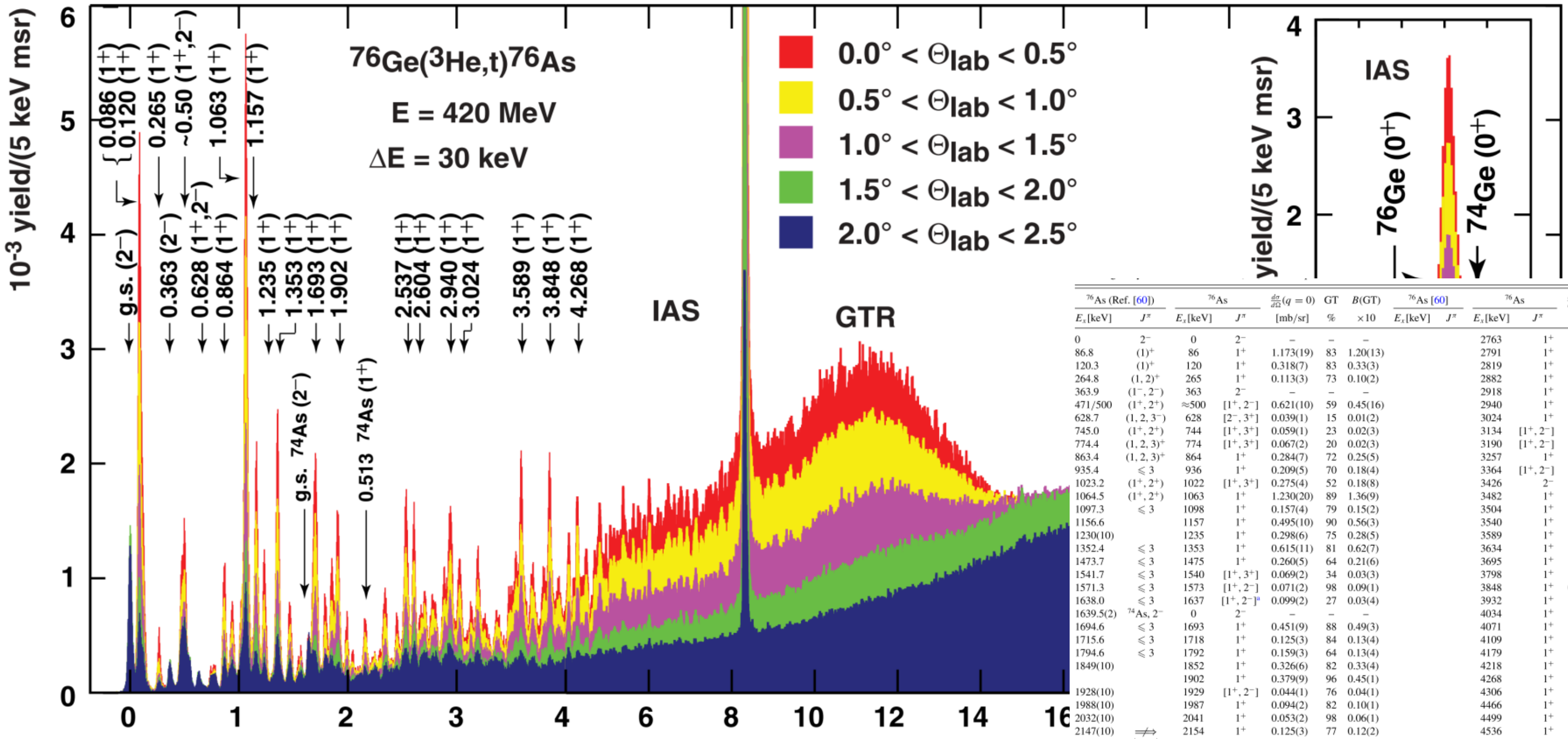
Relative Ratio of Calculated Cross Sections of Neutrino Capturing Reaction $^{71}Ga(\nu,e)^{71}Ge$



1 – σ(tot)/σ(tot – without GTR); 2 – σ(tot)/σ(tot – without GTR and PR1);
3 – σ(tot)/σ(tot –without GTR, PR1 and PR2);
4 – σ(tot)/σ(tot – without GTR, PR1, PR2 and PR3)

76Ge example

Experimental data (76Ge + 74Ge)



^{76}As (Ref. [60]) E_x[keV]	J^π	^{76}As E_x[keV]	J^π	$\frac{d\sigma}{d\Omega}(q=0)$ [mb/sr]	GT %	B(GT) ×10	^{76}As [60] E_x[keV]	J^π	^{76}As E_x[keV]	J^π	$\frac{d\sigma}{d\Omega}(q=0)$ [mb/sr]	GT %	B(GT) ×10
0	2^-	0	2^-	–	–	–			2763	1^+	0.099(2)	64	0.08(2)
86.8	$(1)^+$	86	1^+	1.173(19)	83	1.20(13)			2791	1^+	0.133(3)	86	0.14(1)
120.3	$(1)^+$	120	1^+	0.318(7)	83	0.33(3)			2819	1^+	0.069(2)	47	0.04(2)
264.8	$(1,2)^+$	265	1^+	0.113(3)	73	0.10(2)			2882	1^+	0.193(4)	82	0.20(2)
363.9	$(1^-,2^-)$	363	2^-	–	–	–			2918	1^+	0.107(3)	84	0.11(1)
471/500	$(1^+,2^+)$	≈500	$[1^+,2^-]$	0.621(10)	59	0.45(16)			2940	1^+	0.354(7)	85	0.37(3)
628.7	$(1,2,3^-)$	628	$[2^-,3^+]$	0.039(1)	15	0.01(2)			3024	1^+	0.238(5)	89	0.26(2)
745.0	$(1^+,2^+)$	744	$[1^+,3^+]$	0.059(1)	23	0.02(3)			3134	$[1^+,2^-]$	0.120(3)	82	0.12(1)
774.4	$(1,2,3)^+$	774	$[1^+,3^+]$	0.067(2)	20	0.02(3)			3190	$[1^+,2^-]$	0.254(5)	87	0.27(2)
863.4	$(1,2,3)^+$	864	1^+	0.284(7)	72	0.25(5)			3257	1^+	0.097(2)	73	0.09(2)
935.4	$\leqslant 3$	936	1^+	0.209(5)	70	0.18(4)			3364	$[1^+,2^-]$	0.070(2)	64	0.06(2)
1023.2	$(1^+,2^+)$	1022	$[1^+,3^+]$	0.275(4)	52	0.18(8)			3426	2^-	–	–	–
1064.5	$(1^+,2^+)$	1063	1^+	1.230(20)	89	1.36(9)			3482	1^+	0.107(3)	83	0.11(1)
1097.3	$\leqslant 3$	1098	1^+	0.157(4)	79	0.15(2)			3504	1^+	0.062(3)	89	0.07(1)
1156.6		1157	1^+	0.495(10)	90	0.56(3)			3540	1^+	0.230(5)	88	0.25(2)
1230(10)		1235	1^+	0.298(6)	75	0.28(5)			3589	1^+	0.421(9)	91	0.48(2)
1352.4	$\leqslant 3$	1353	1^+	0.615(11)	81	0.62(7)			3634	1^+	0.106(3)	80	0.11(1)
1473.7	$\leqslant 3$	1475	1^+	0.260(5)	64	0.21(6)			3695	1^+	0.227(5)	85	0.24(2)
1541.7	$\leqslant 3$	1540	$[1^+,3^+]$	0.069(2)	34	0.03(3)			3798	1^+	0.181(5)	95	0.21(1)
1571.3	$\leqslant 3$	1573	$[1^+,2^-]$	0.071(2)	98	0.09(1)			3848	1^+	0.441(10)	97	0.53(1)
1638.0	$\leqslant 3$	1637	$[1^+,2^-]$[a]	0.099(2)	27	0.03(4)			3932	1^+	0.186(5)	93	0.22(1)
1639.5(2)	^{74}As, 2^-	0	2^-	–	–	–			4034	1^+	0.119(3)	87	0.13(1)
1694.6	$\leqslant 3$	1693	1^+	0.451(9)	88	0.49(3)			4071	1^+	0.239(6)	91	0.27(1)
1715.6	$\leqslant 3$	1718	1^+	0.125(3)	84	0.13(4)			4109	1^+	0.052(1)	66	0.04(1)
1794.6	$\leqslant 3$	1792	1^+	0.159(3)	64	0.13(4)			4179	1^+	0.103(3)	92	0.12(1)
1849(10)		1852	1^+	0.326(6)	82	0.33(4)			4218	1^+	0.116(4)	95	0.14(1)
		1902	1^+	0.379(9)	96	0.45(1)			4268	1^+	0.294(7)	93	0.34(1)
1928(10)		1929	$[1^+,2^-]$	0.044(1)	76	0.04(1)			4306	1^+	0.187(4)	89	0.21(1)
1988(10)		1987	1^+	0.094(2)	82	0.10(1)			4466	1^+	0.094(3)	83	0.10(1)
2032(10)		2041	1^+	0.053(2)	98	0.06(1)			4499	1^+	0.167(4)	92	0.19(1)
2147(10)	$\not\Rightarrow$	2154	1^+	0.125(3)	77	0.12(2)			4536	1^+	0.055(2)	94	0.06(1)
2153(2)	^{74}As(1^+)	513.8	1^+	0.725(17)	77	0.71(10)			4668	1^+	0.046(1)	76	0.04(1)
2338(10)		2338	1^+	0.184(4)	83	0.19(2)			4699	1^+	0.153(6)	100	0.19(1)
2446(10)		2449	1^+	0.111(3)	67	0.09(2)			4738	1^+	0.137(4)	91	0.16(1)
		2537	1^+	0.377(7)	87	0.41(3)			4801	1^+	0.261(6)	92	0.30(1)
		2604	1^+	0.347(7)	76	0.33(5)			4841	1^+	0.234(6)	97	0.28(1)
		2657	1^+	0.096(2)	69	0.08(2)			4941	1^+	0.101(3)	94	0.12(1)
		2688	1^+	0.122(3)	83	0.13(1)			4978	1^+	0.151(4)	87	0.16(1)
		2716	1^+	0.126(3)	60	0.09(3)						$\Sigma =$	16.0(18) / 14.8(17)

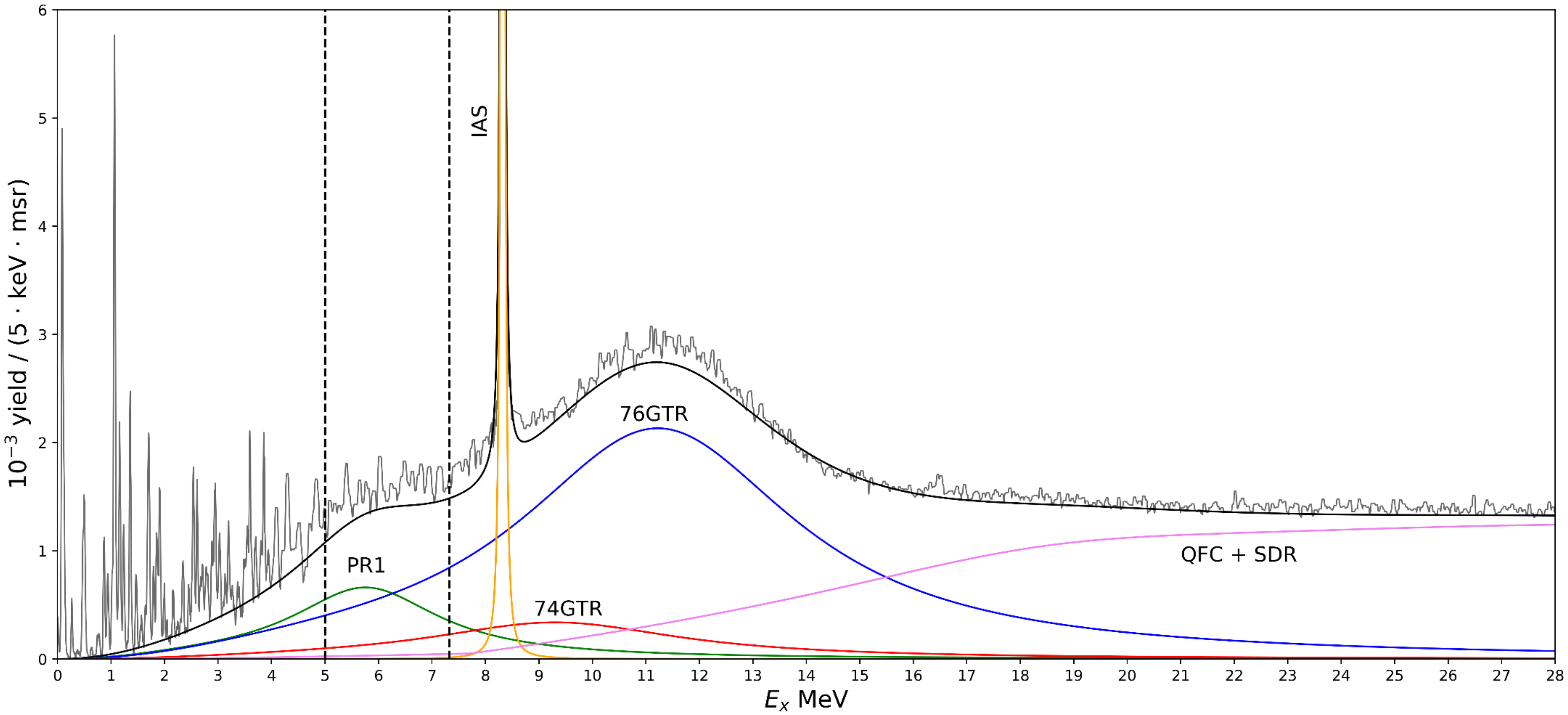
[a]Composed of a ^{76}As 1^+ state and the ^{74}As 2^- g.s. (next line)

J. H. Thies et al.,
PHYSICAL REVIEW C **86**, 014304 (2012)

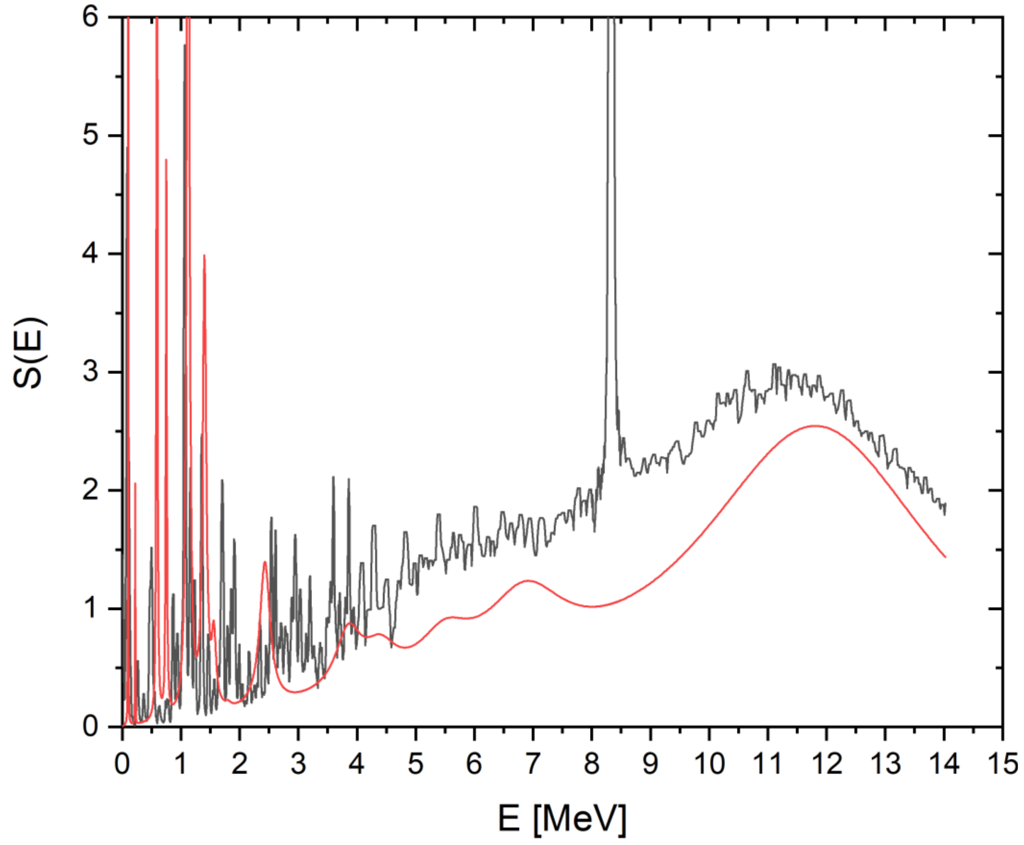
Experimental data and Fitting (76Ge+74Ge)

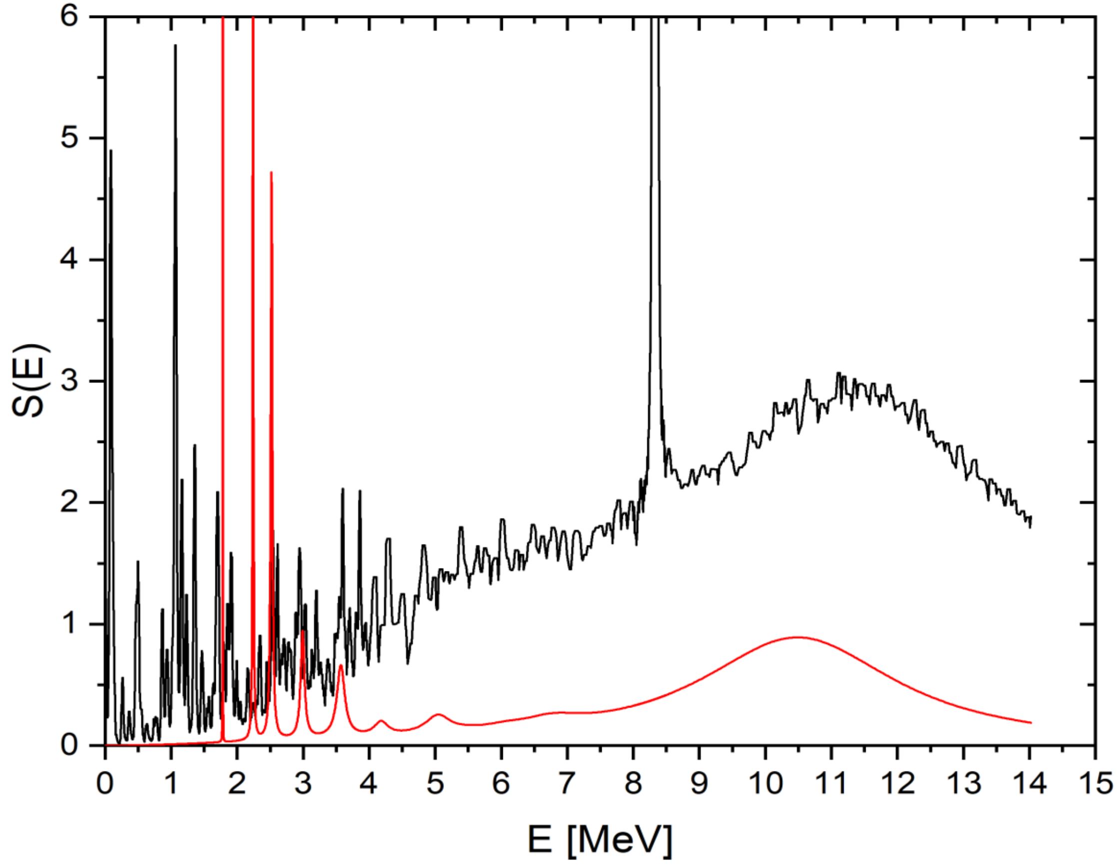
J. Thies, D. Frekkers et al. Phys. Rev. C. 86.
10.1103/PhysRevC.86.014304

$(0.0° - 0.5°)$

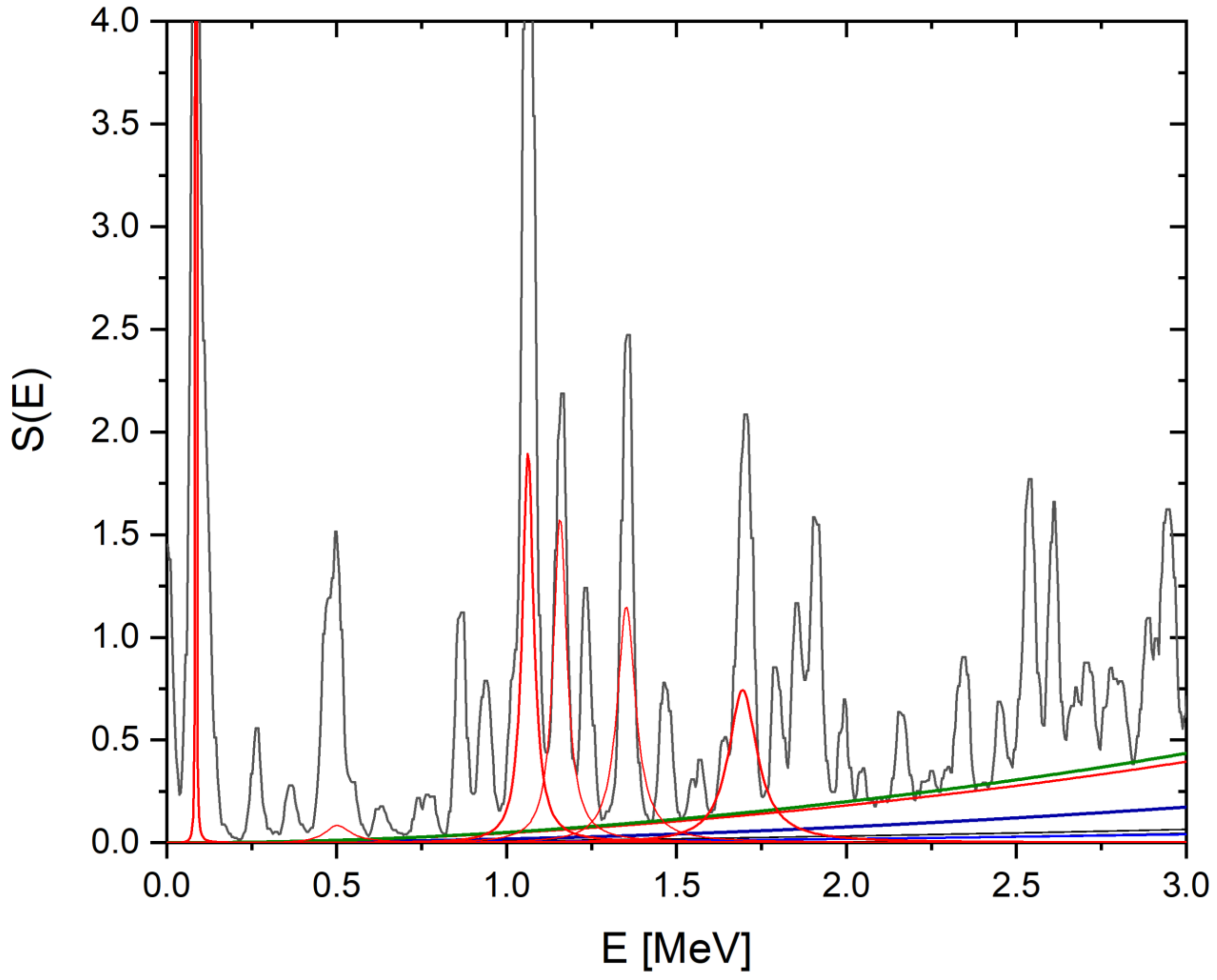


Theoretical Strength function for 76Ge and 74Ge



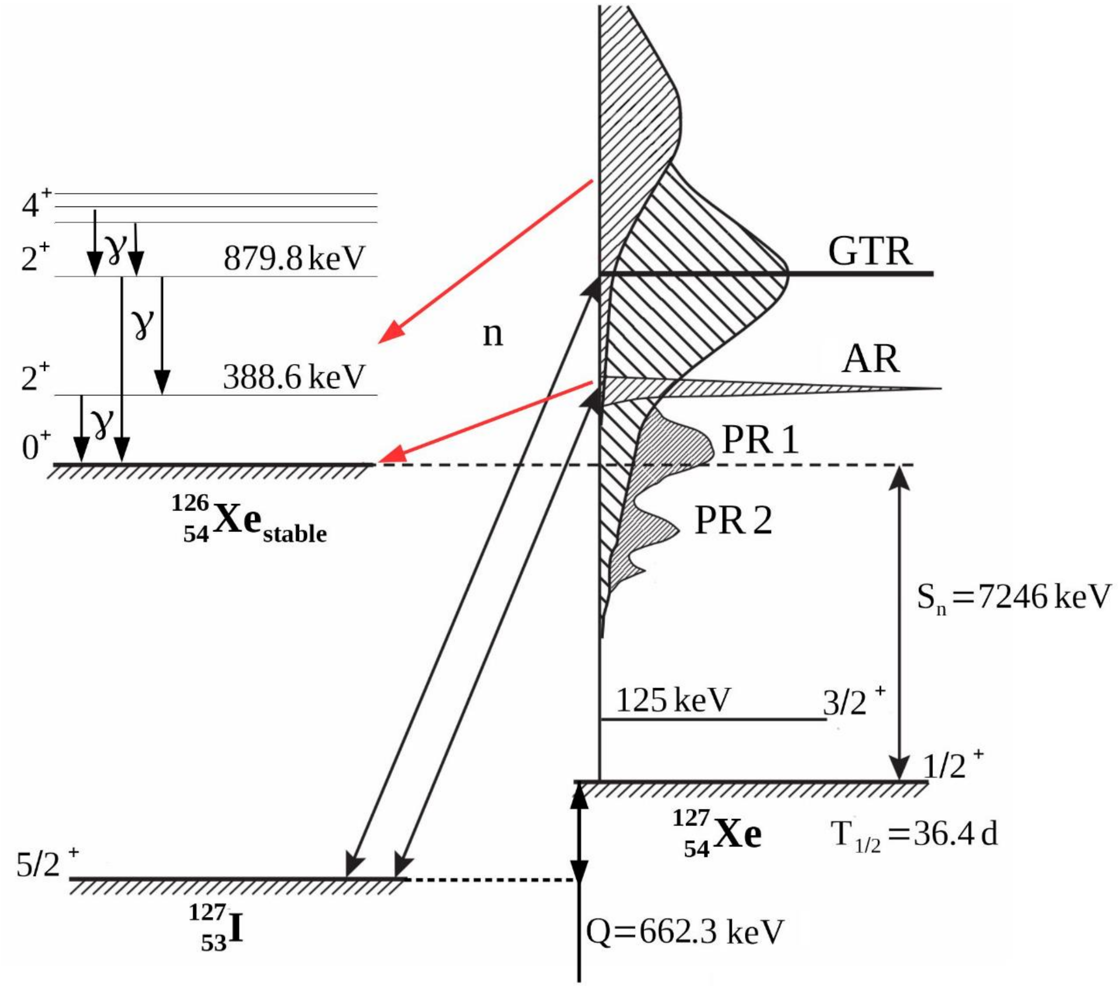


Theoretical Strength function for 76Ge + 74Ge
(low energy part)



Large Iodine Detector and Neutron emission

127Xe

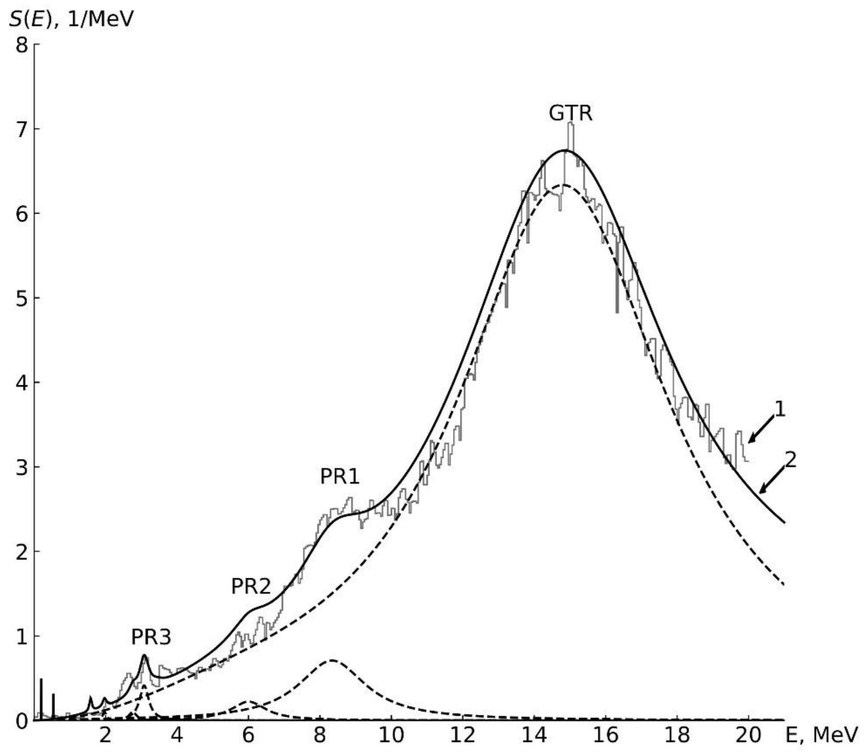


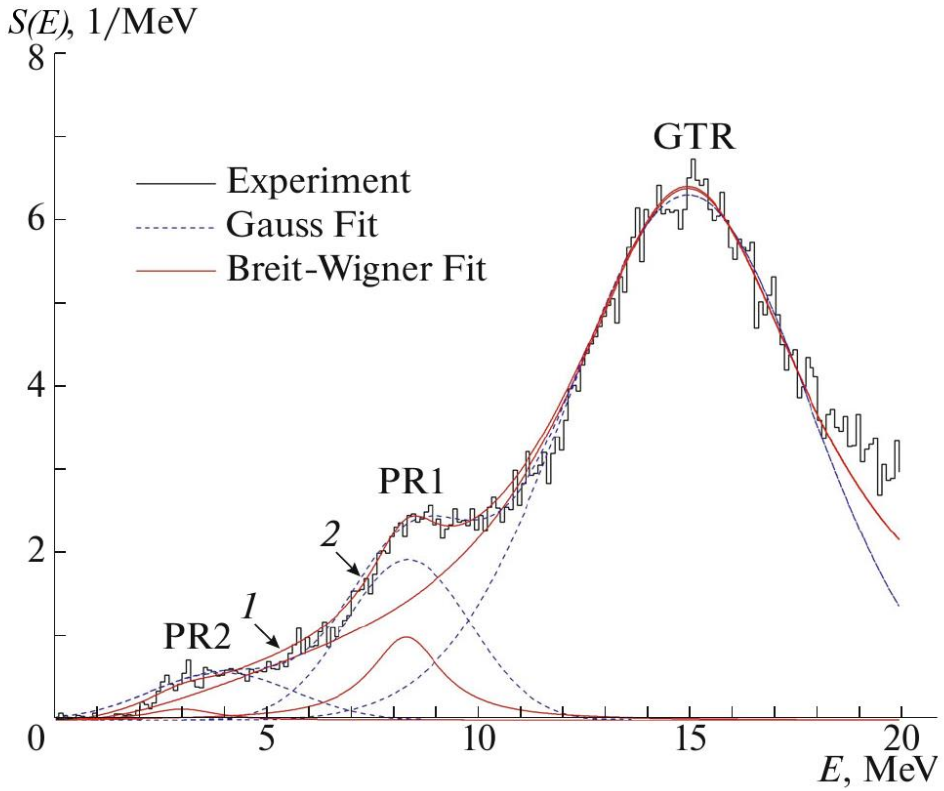
$$\nu_e + {}^{127}\mathrm{I} \rightarrow e^- + {}^{127}\mathrm{Xe}$$

Scheme of charge-exchange excitations of the 127Xe nucleus in the 127I(*p; n*)127Xe reaction with the decay of highlying excitations in the stable 126Xe isotope accompanied by the emission of a neutron. The giant Gamow-Teller resonance (GTR), analog resonance(AR), and lower lying Gamow-Teller pygmy resonances (PR) are indicated; *Sn* is the neutron separation energy in the 127Xe nucleus.

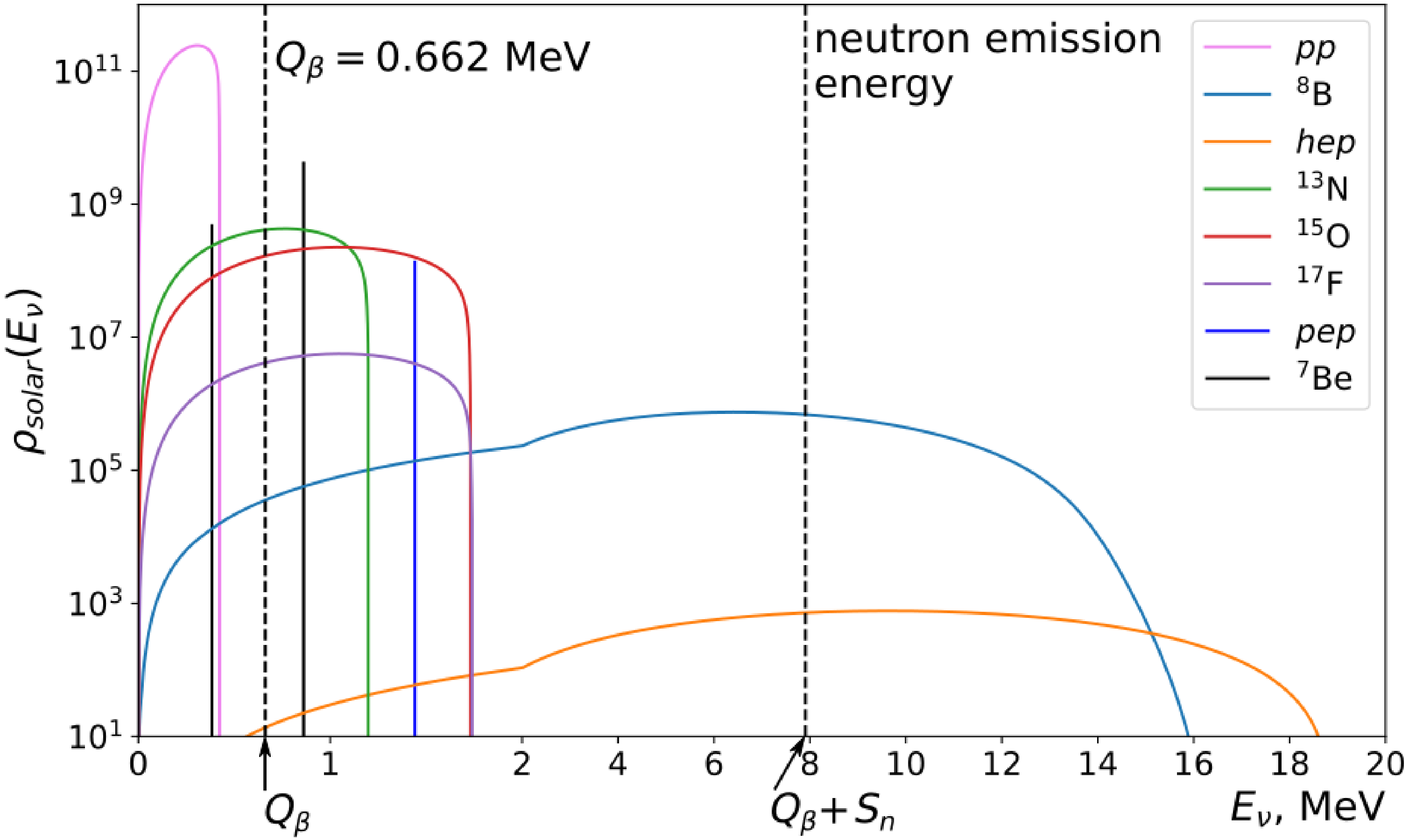
Theoretical vs. Experimental Strength Function

M. Palarczyk, J. Rapaport, C. Hautala, *et al.*,
Measurement of Gamow-Teller strength for 127I as a solar neutrino detector, Phys. Rev. C **59**, 500 (1999)





Solar neutrino spectrum and capture rate



$$R = \int_0^{E_{max}} \rho_{solar}(E_\nu)\sigma_{solar}(E_\nu)dE_\nu$$

$$R_{total} = R_{discr} + R_{res}$$

Neutron emission role and GT resonances influence

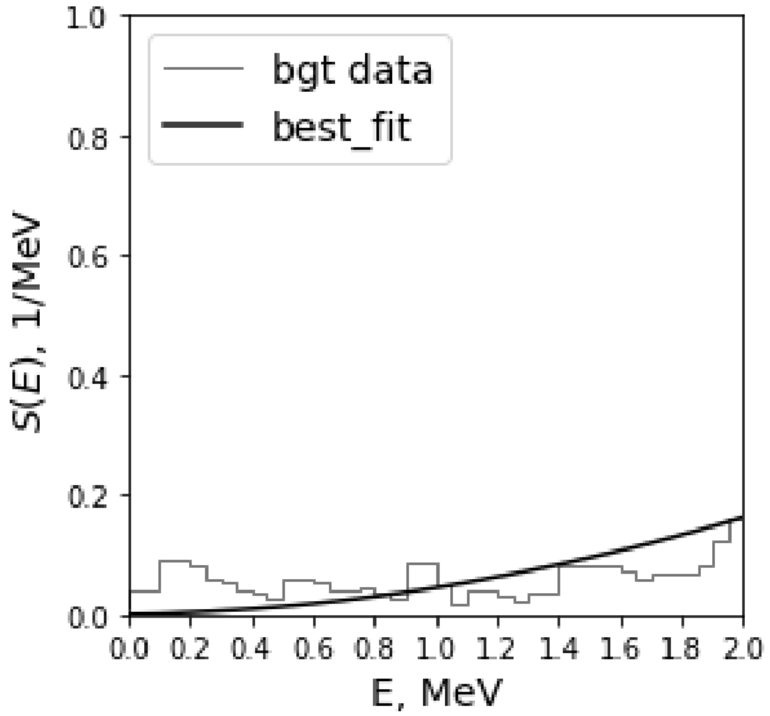
Rate of neutrino capture without neutron emission from the ^{127}Xe nucleus							
	^{8}B	*hep*	^{13}N	^{15}O	^{17}F	^{7}Be	Total
R-total	33.232	0.204	0.168	0.514	0.013	3.031	37.904
R without GTR	9.818	0.047	0.165	0.483	0.012	3.012	14.223
R without GTR and PR1	6.018	0.019	0.164	0.468	0.012	3.002	10.345
Rate of neutrino capture with neutron emission from the ^{127}Xe nucleus							
R-total	27.889	0.117	0.168	0.514	0.013	3.031	32.474
R without GTR	8.324	0.030	0.165	0.483	0.012	3.012	12.713
R without GTR and PR1	6.011	0.019	0.164	0.468	0.012	3.002	10.337

127I vs 37Cl detectors

TABLE II. Comparison of sensitivities to ^{7}Be and ^{8}B solar neutrinos between ^{127}I and ^{37}Cl detectors. The total cross sections are in units of 10^{-45} cm^2.

	^{127}I	^{37}Cl
^{7}Be	1.22 ± 0.40	0.24 ± 0.02
^{8}B	$(4.3\pm0.6)\times10^3$	$(1.11\pm0.08)\times10^3$
Ratio ^{8}B/^{7}Be	3525 ± 1260	4625 ± 510

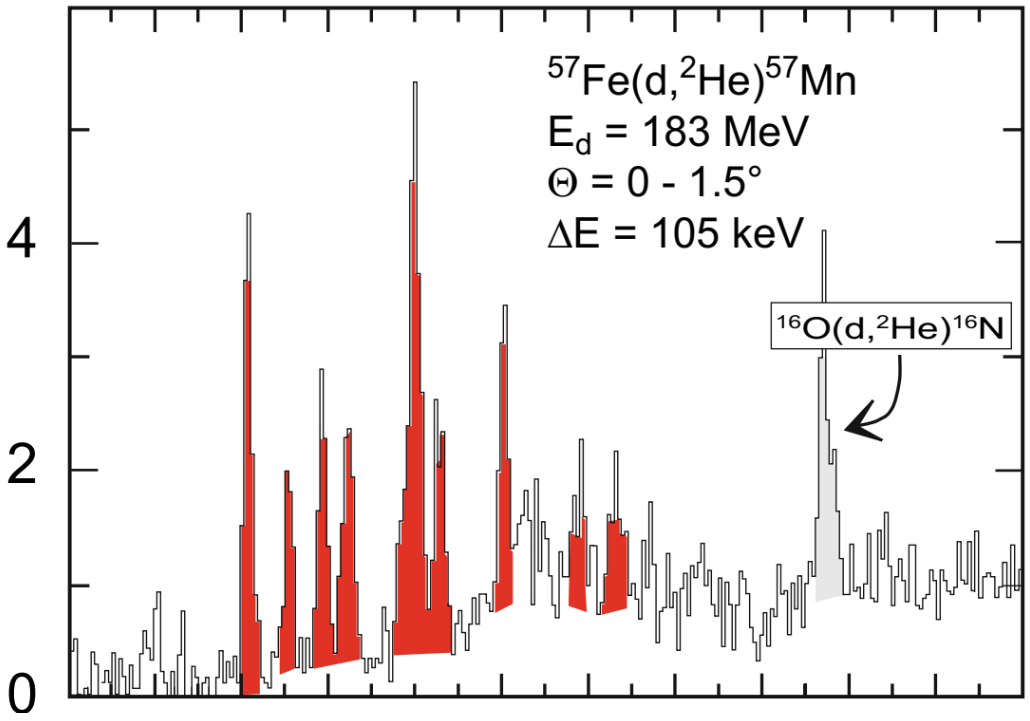
S(E) experimental data for 127I



Uncertainties at low energies

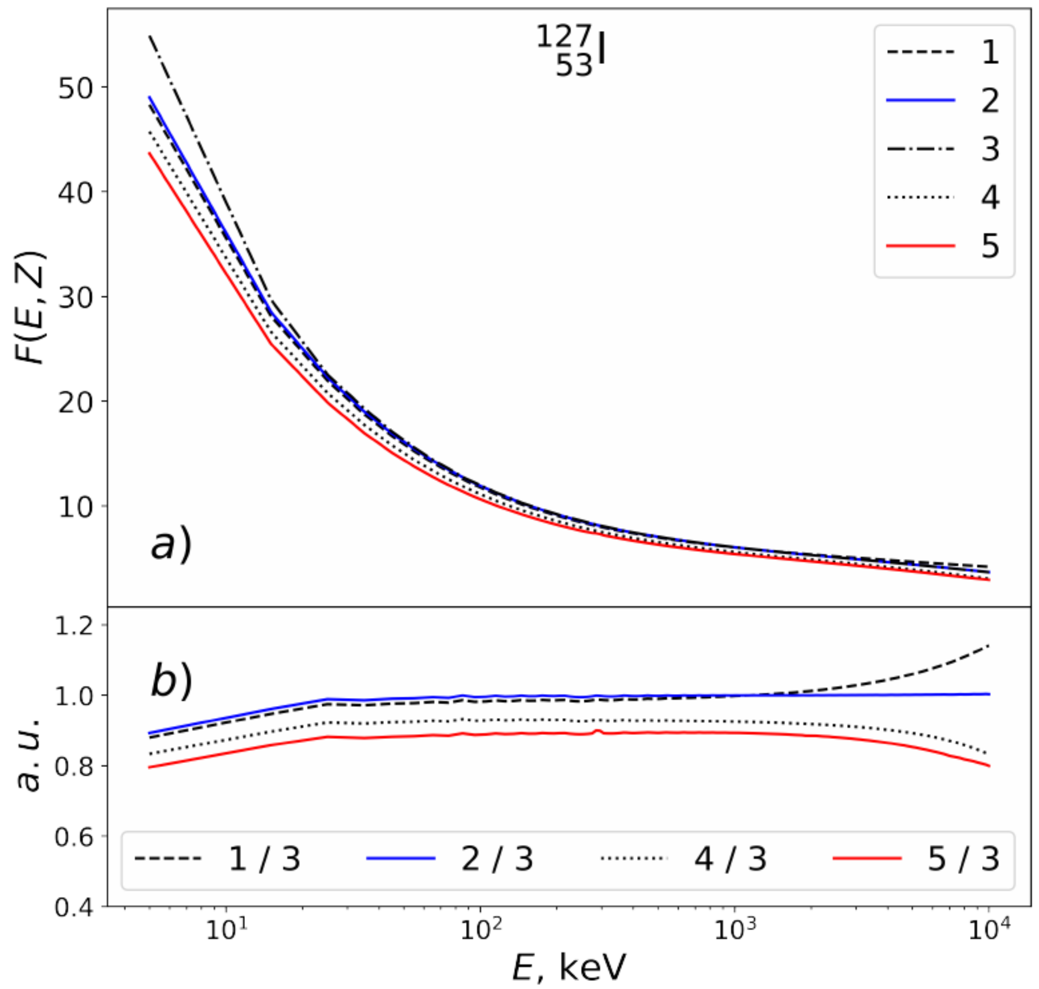
D. Frekers and M. Alanssari

Eur. Phys. J. A (2018) ***54****: 177*



- Difficulties in B(GT) extraction for all charge-exchange reactions
- Uncertainties of Fermi function!
- …

Fermi functions



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3 - H. Behrens and J. J¨anecke,Numerical Tables for Beta-Decay and Electron Capture, Landolt-Boernstein - Group I Elementary Particles,Nuclei and Atoms (Springer, 1969).

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Conclusions

- GT resonances plays significant role in neutrino capture process and could be investigated using charge-exchange reactions
- TFFS is good for accurate description resonant part of strength function
- Quenching effect is still not closed issue
- New detector based on 127I could be sensitive to the high-energy part of the solar neutrino spectrum
-

Thank you for your attention!