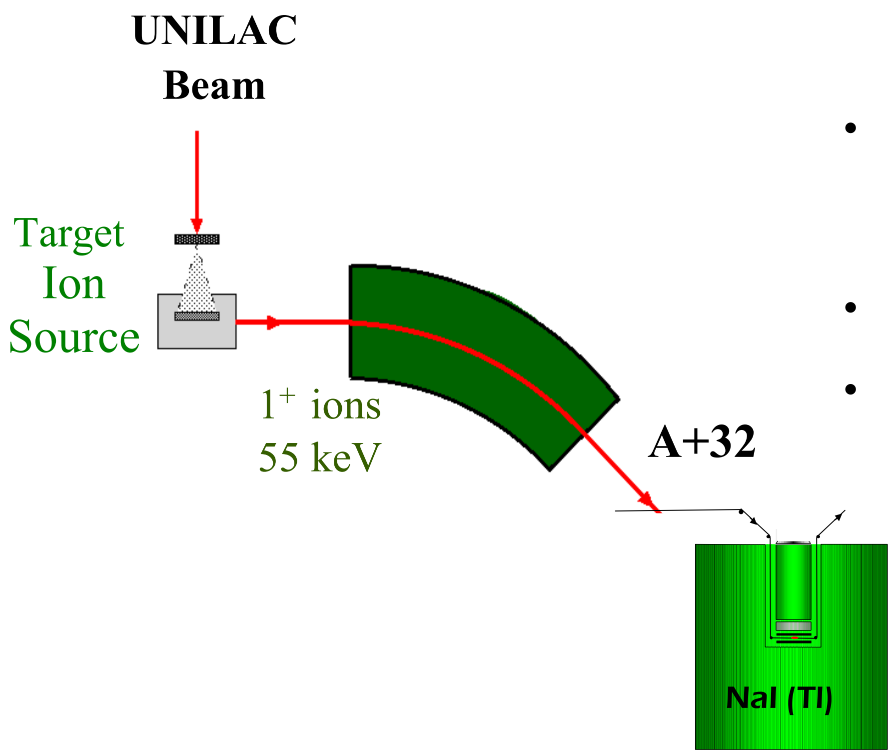
Систематика состояний Гамова-Теллера возбуждаемых в β^+/EC распаде ядер вблизи N,Z=50

(по результатам измерений в GSI)

- **Suppression of the Gamow-Teller strength**
- **Isotopic dependence of energy and strength of the neutron-deficient nuclei with $44 \leq Z \leq 50$; $N \geq 50$**
- **Extrapolation to ^{100}Sn и ^{101}Sn**
- **allowed β_+ Gamow-Teller decays of the nuclei far from stability**
- **Nuclei with $N<50$ and excitation across the $N=50$ core**

GSI On-Line Mass Separator



ISOL

- Fusion-evaporation reaction, ~5 MeV/u ^{58}Ni beam, enriched 3mg/cm^2 ^{50}Cr target
- Extraction and ionization of 1^+ ions
- Post acceleration to 55 keV

$$^{50}\mathrm{Cr} + {}^{58}\mathrm{Ni} \rightarrow \begin{cases} {}^{103}\mathrm{Sn} + \alpha + 1n \\ {}^{105}\mathrm{Sn} + 2p + 1n \end{cases}$$

Ion source chemistry

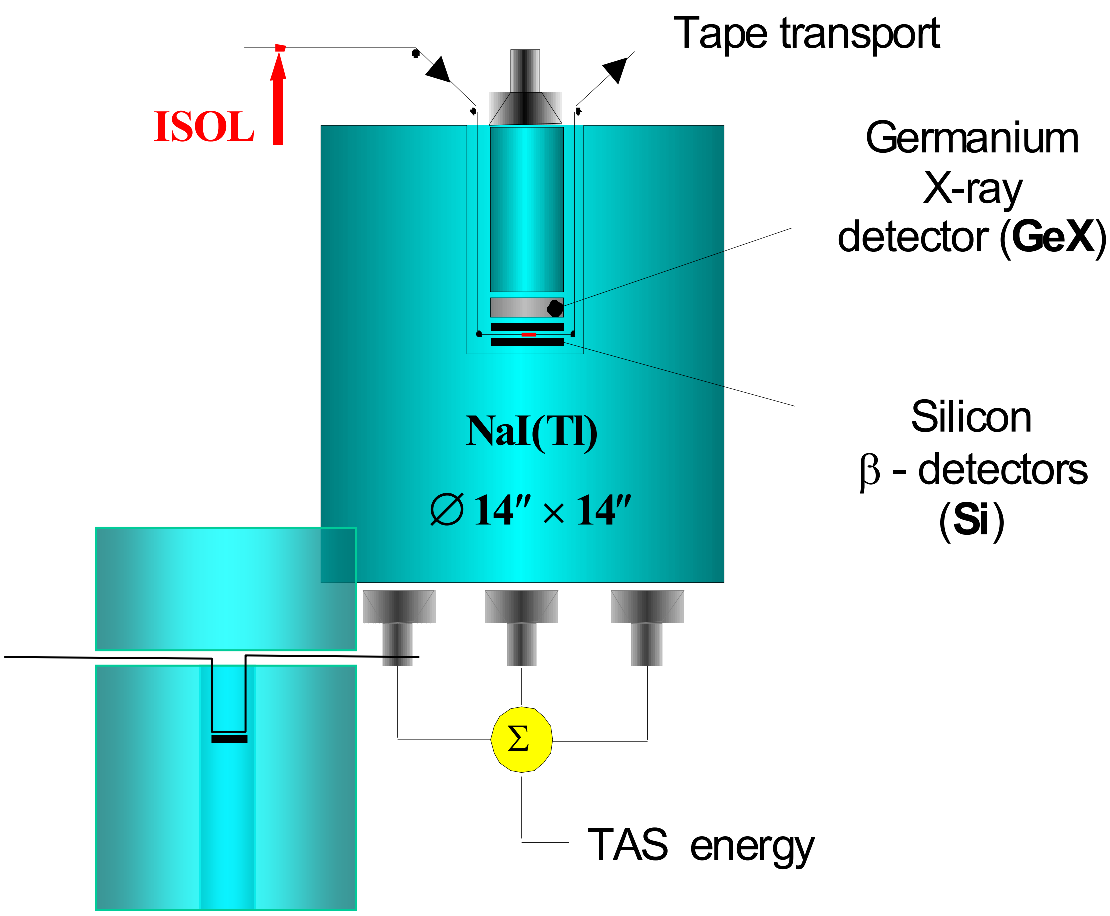
Suppression of neighbouring lower-Z isobars:

In, Cd, Ag and Pd,

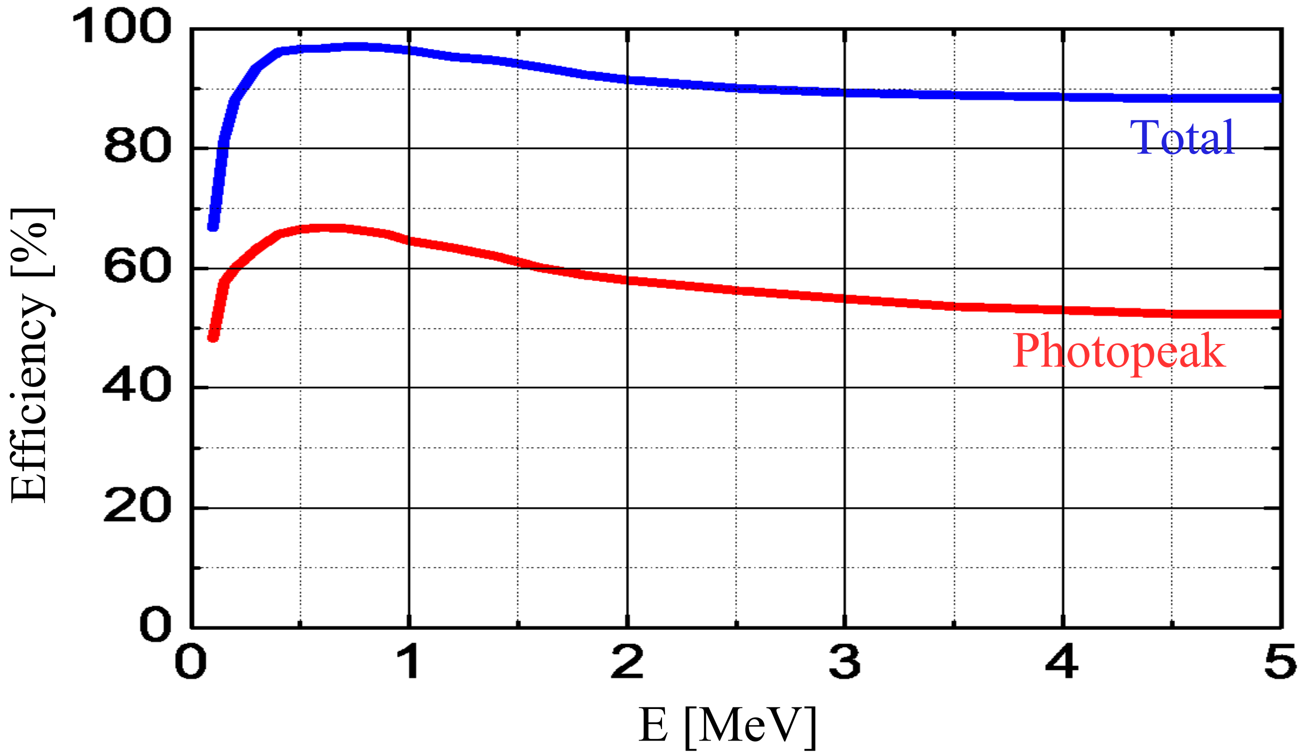
by using mass separation of molecular $^{A}Sn^{32}S^{+}$ beams, A+32 [1]

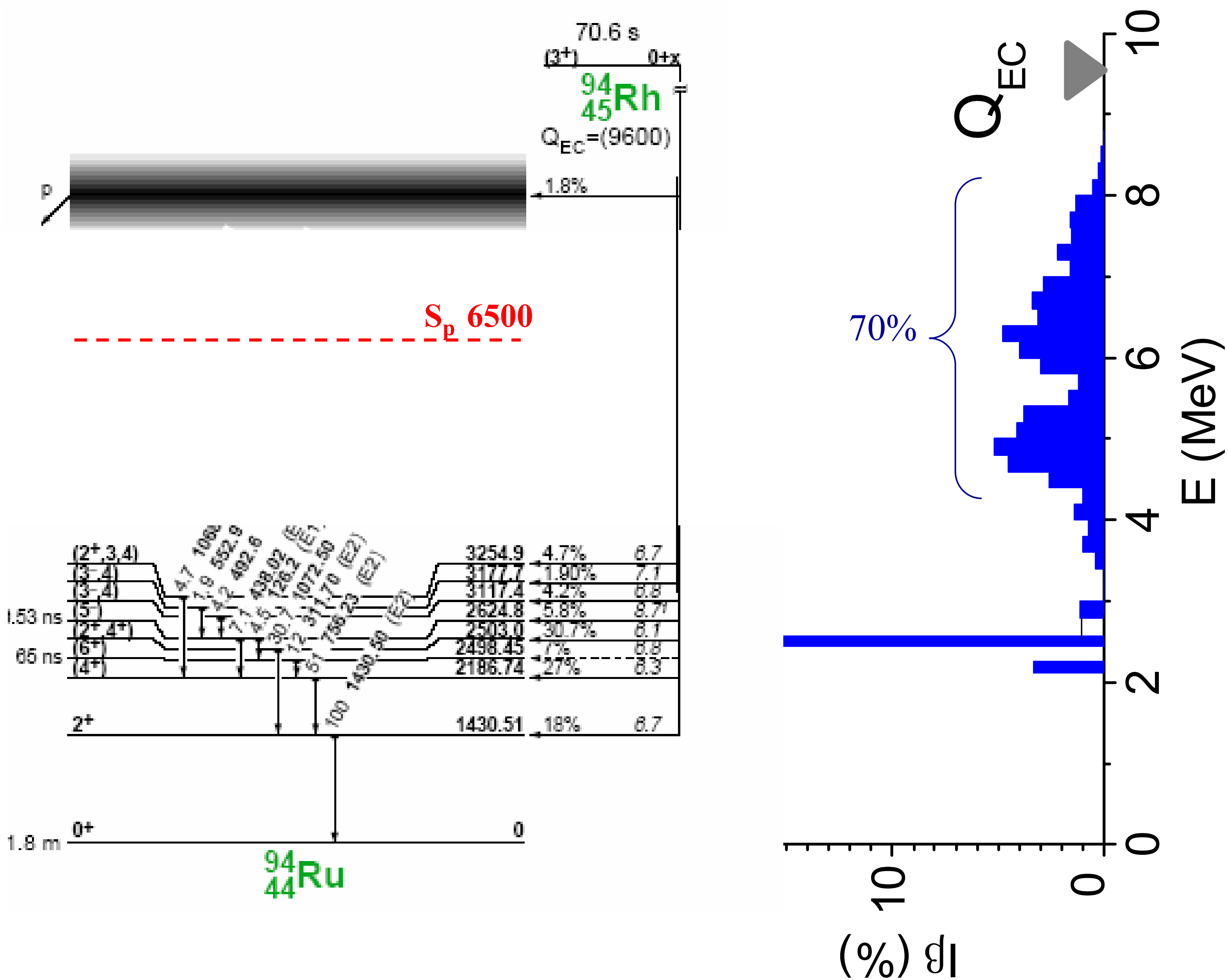
[1] R. Kirchner, NIM B 204 (2003) 179

Total-Absorption Spectrometer (TAS)



TAS Efficiency

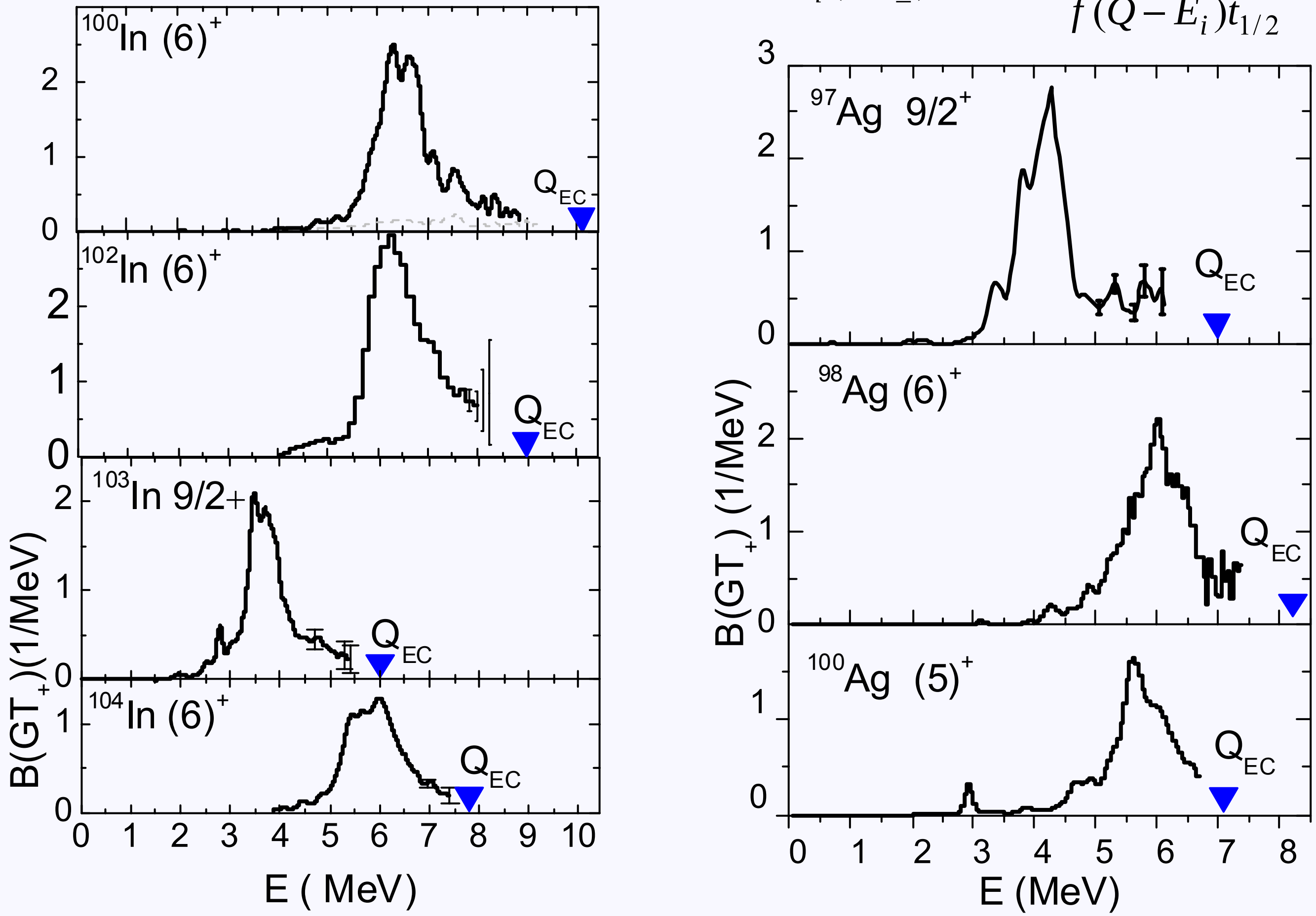




70.6 s
(3+)
0+x
94 45 Rh
QEC=(9600)
1.8%
p
Sp 6500
(2+,3,4)
(3-4)
(3-4)
(5-)
(2+,4+)
(6+)
(4+)
2+
0+
3254.9
3177.7
3117.4
2624.8
2503.0
2498.45
2186.74
1430.51
0
4.7%
1.90%
4.2%
5.8%
30.7%
7%
27%
18%
6.7
7.1
6.8
6.7
6.1
6.8
6.3
6.7
1.53 ns
65 ns
1.8 m
94 44 Ru
QEC
70%
E (MeV)
Iβ (%)
0
2
4
6
8
10
0
10

Gamow-Teller strength distributions

$$B_i(\mathrm{GT}_\pm) = 3860 \frac{I^i{}_{\beta_\pm}}{f(Q - E_i)t_{1/2}}$$



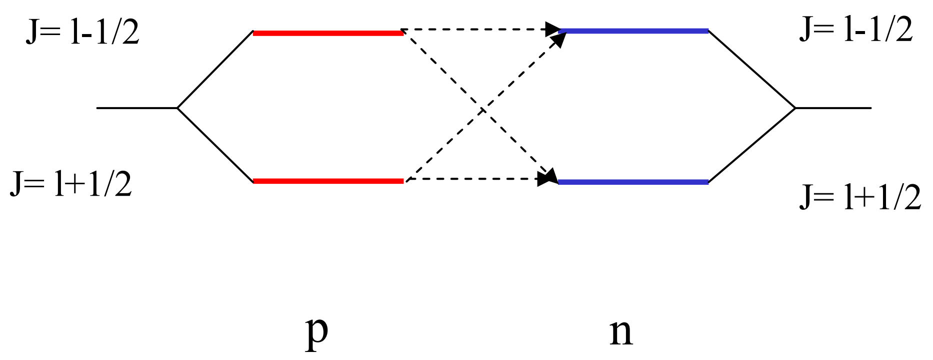
^{100}In: C.Plettner et al., Phys. Rev. C66, 044319 (2002)
^{102}In: M. Gierlik et al., Nucl. Phys. A724, 313 (2003)
^{103}In: M. Karny et al., Nucl. Phys. A640, 3 (1998)
$^{104-107}$In: M. Karny et al., Nucl.Phys. A690, 367 (2001)

97,98Ag: Z. Hu et al., Phys. Rev. C60, 024315 (1999), C60, 064315 (2000)
^{100}Ag: L. Batist et al., Z.Phys. A351, 149 (1995)

$$GT_{\pm} = \sum_{A} \sigma_{\mu} t_{\pm}$$

Single-particle transition $p \leftrightarrow n, \quad nlj \rightarrow nlj'$

$$|Z_i - Z_f| = 1; \quad I_i^{\pi} \rightarrow I_f^{\pi}; \quad |I_i - I_f| \leq 1$$



Gamow-Teller operator

$$GT_{\pm} = \sum_{A} \sigma_{\mu} t_{\pm}$$

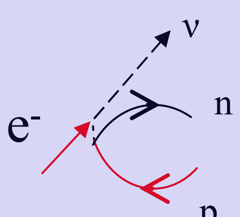
$$B(\mathrm{GT}_{\pm}) = (2I_i + 1)^{-1} \,|< f \,\|\, GT_{\pm} \,\|\, i >|^2$$

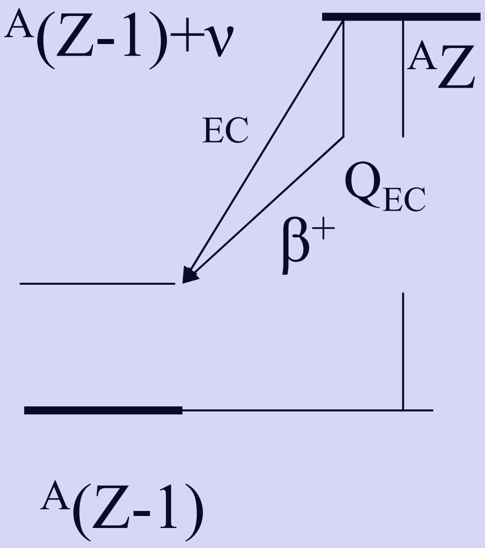
Beta decay

$$I_i / t_{1/2} = \frac{1}{3860} \cdot f\,(Q - E_i)\; B(\mathrm{GT}_{\pm})$$

$$f = f_{\varepsilon} + f_{\beta}$$

$${}^{A}Z + e^{-} \longrightarrow {}^{A}(Z\text{-}1) + \nu$$

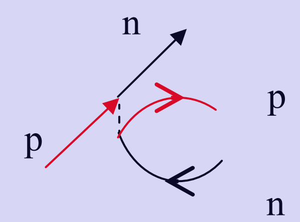




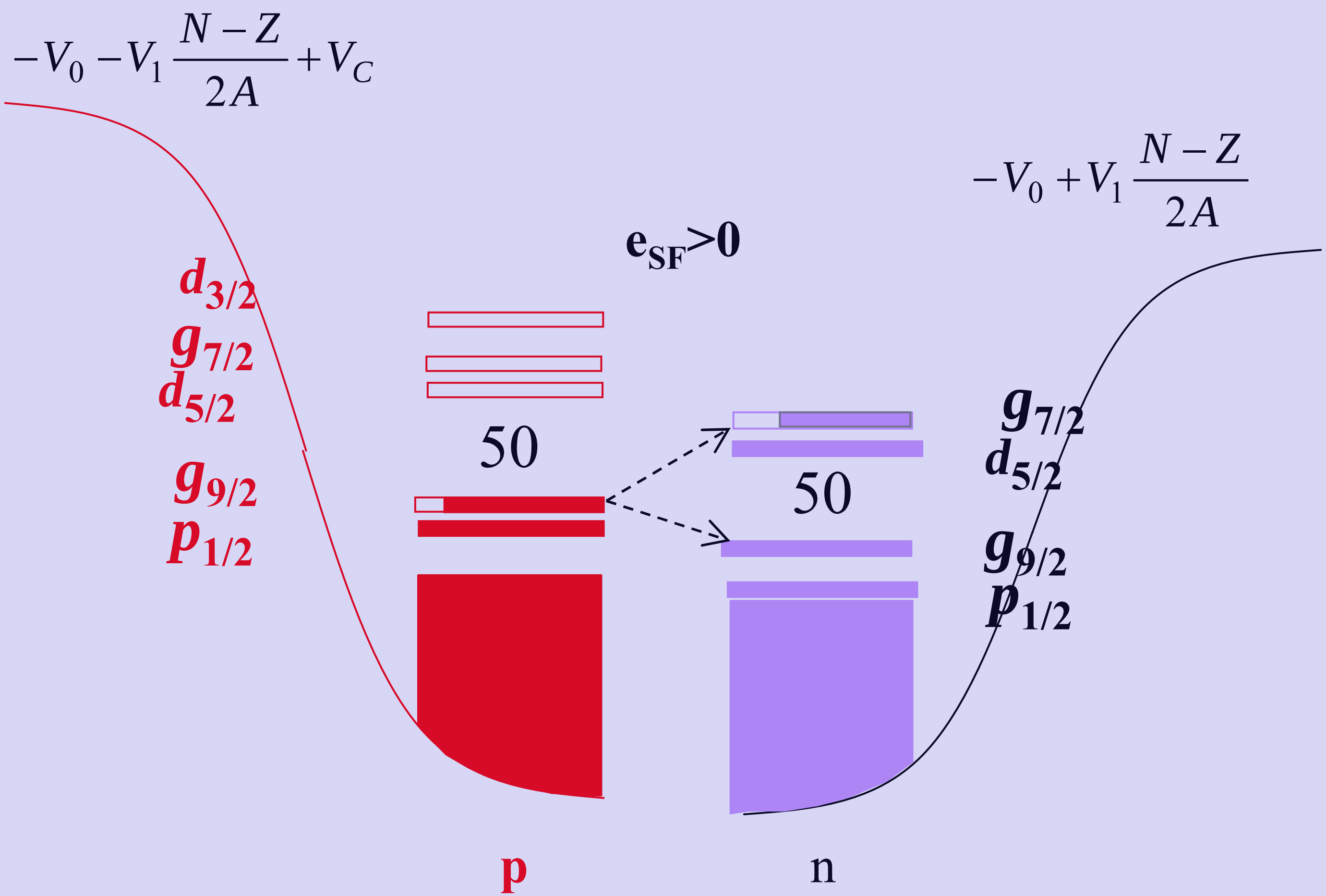
Spin-charge exchange reaction

$$\partial\sigma_{\pm}(q = 0) \sim B(\mathrm{GT}_{\pm})$$

$${}^{A}Z + p \longrightarrow {}^{A}(Z+1) + n$$

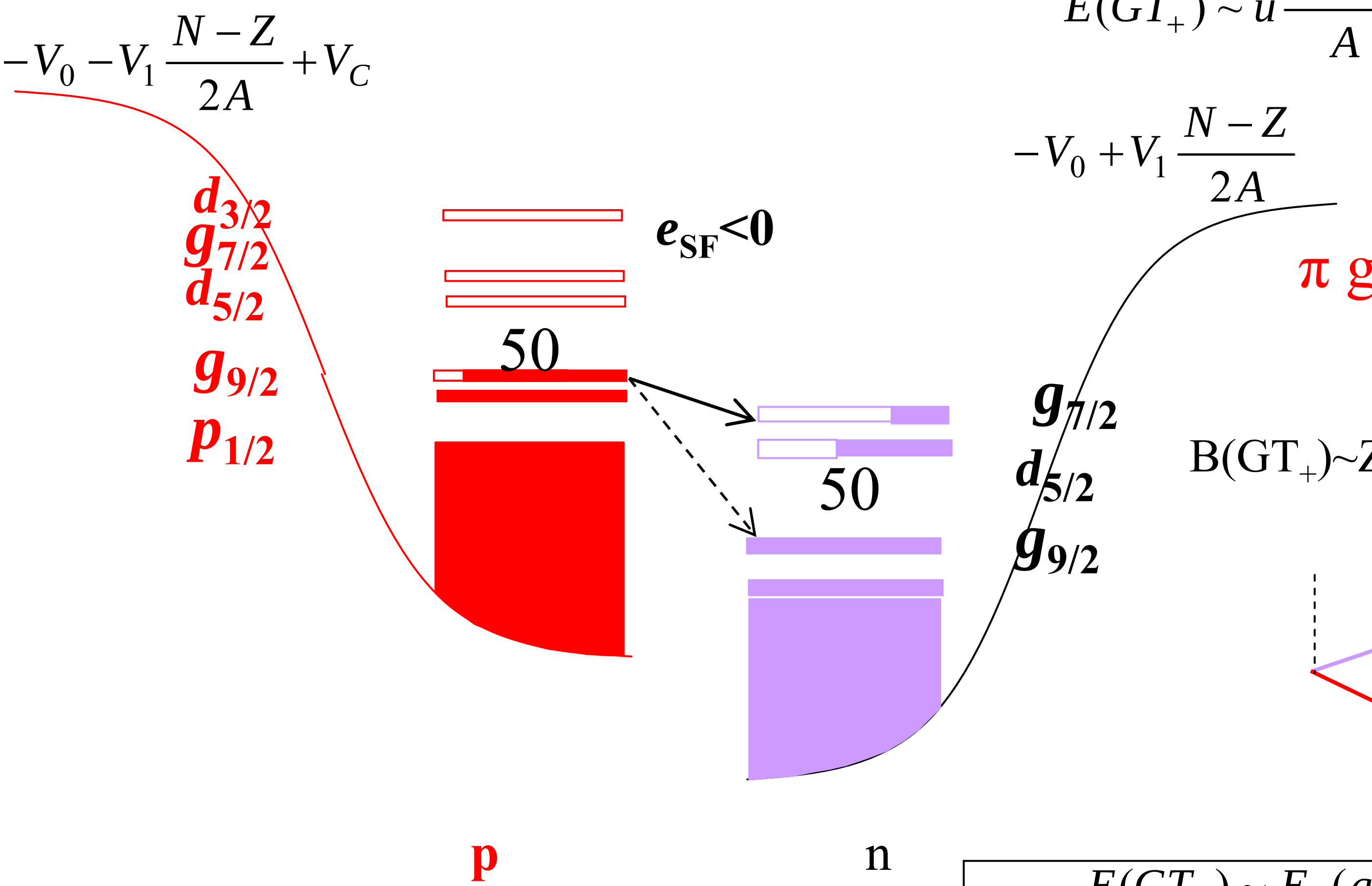


CLOSE TO STABILITY



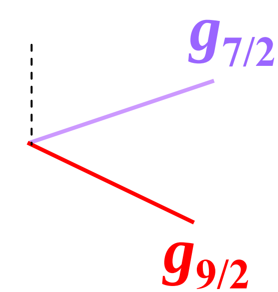
neutron-deficient region (near ^{100}Sn)

$$E(GT_+) \sim u\frac{N-Z}{A} - \delta V_C + e_{SO} + H_{INT}$$



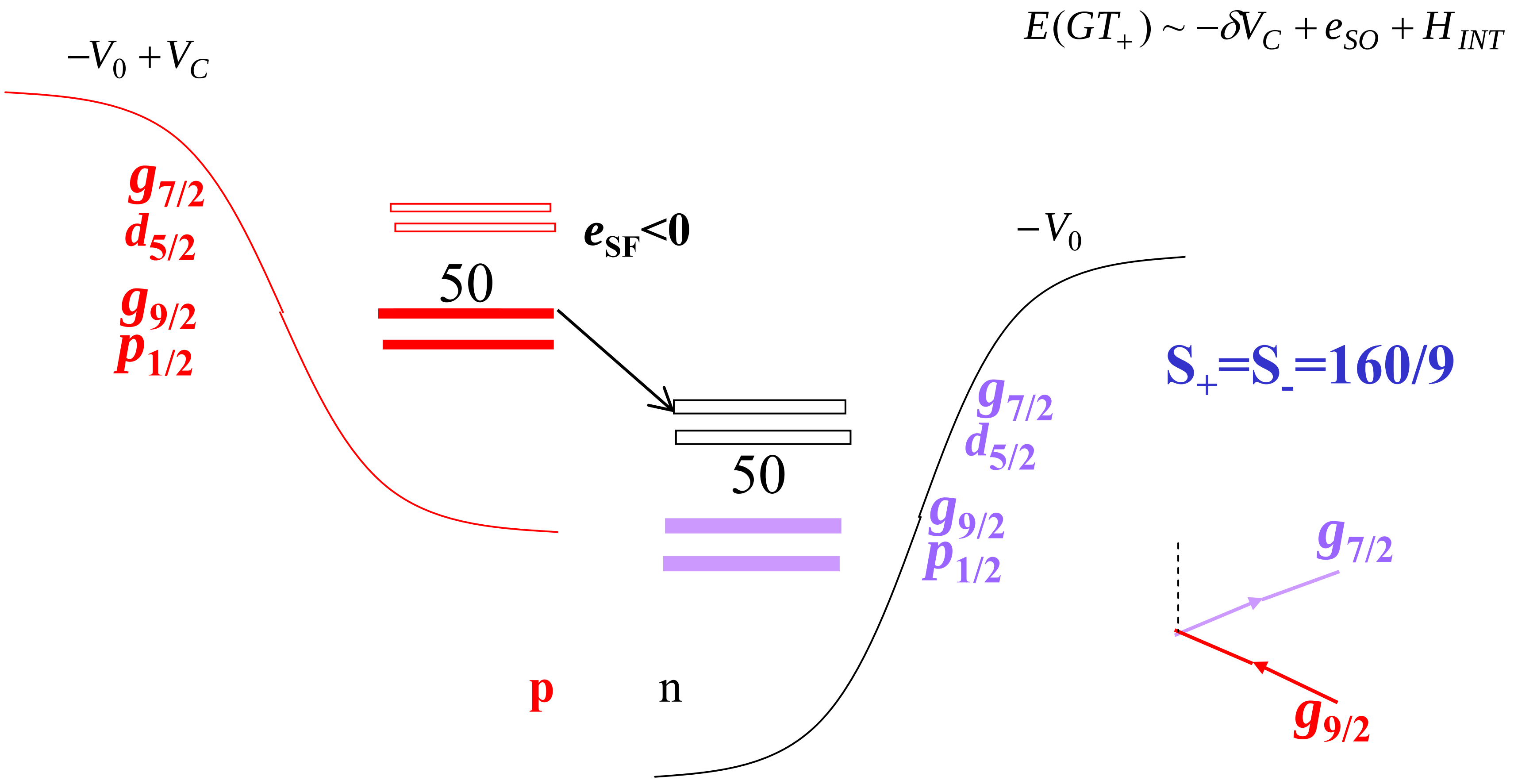
$\pi\, g_{9/2} \rightarrow \nu g_{7/2}$

$B(GT_+) \sim Z(g_{9/2})(1-N(g_{7/2})/8)$



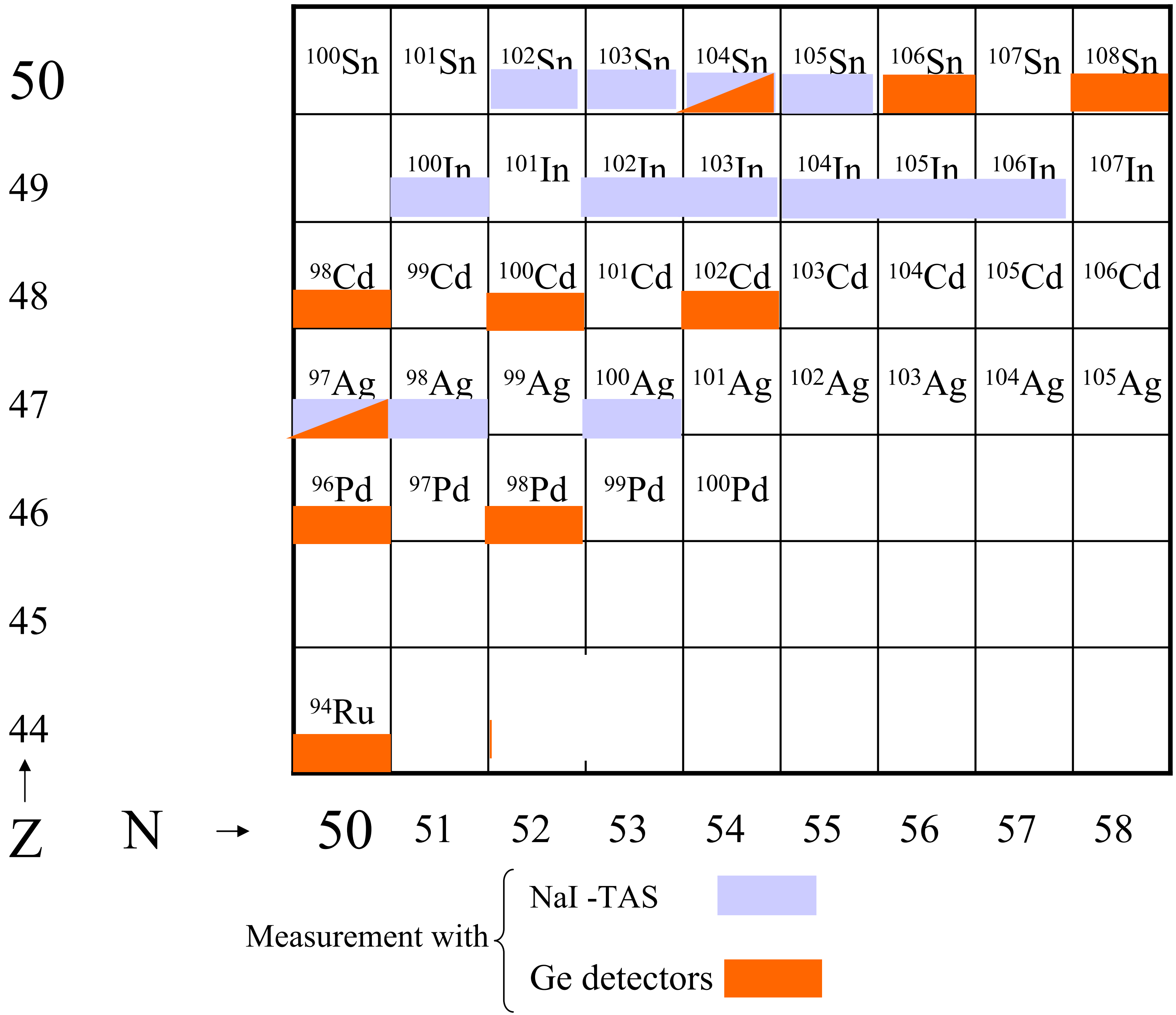
$$E(GT_+) \sim E_n(g_{7/2}) + E_p(g_{9/2}) + H_{INT} + (\lambda_n - \lambda_p)$$

^{100}Sn



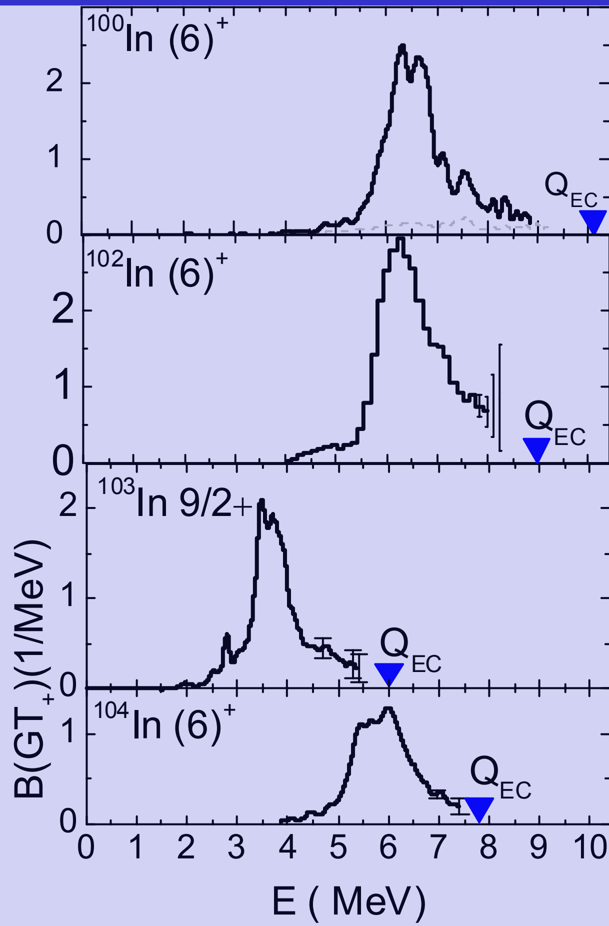
$E(GT_+) \sim -\delta V_C + e_{SO} + H_{INT}$
$-V_0 + V_C$
$g_{7/2}$
$d_{5/2}$
$g_{9/2}$
$p_{1/2}$
$e_{SF}<0$
50
50
$-V_0$
$S_+=S_-=160/9$
$g_{7/2}$
$d_{5/2}$
$g_{9/2}$
$p_{1/2}$
$g_{7/2}$
$g_{9/2}$
p
n

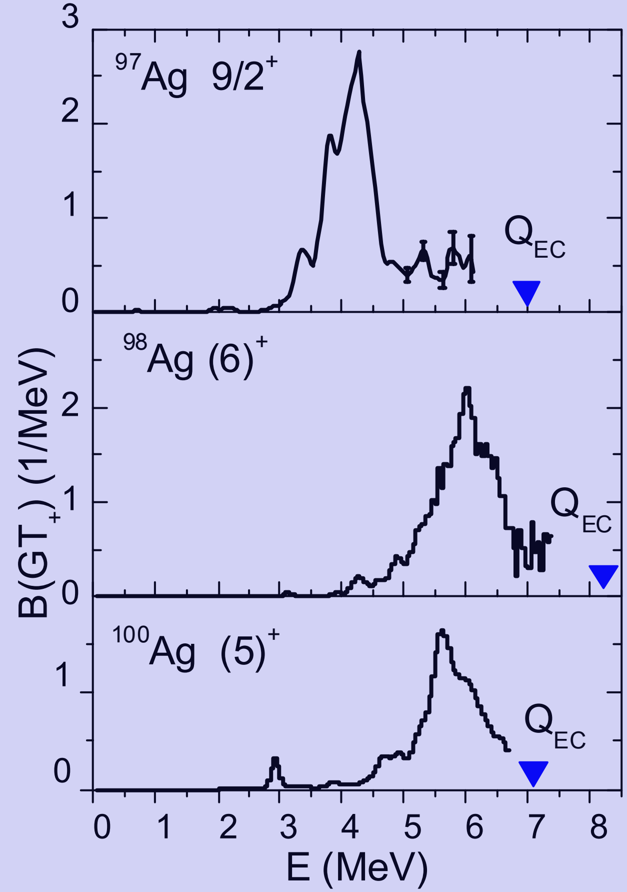
Data used for systematics of GT^+ properties



Gamow-Teller strength distributions

$$B_i(GT_\pm) = 3860 \frac{I^i_{\beta_\pm}}{f(Q-E_i)t_{1/2}}$$





^{100}In: C.Plettner et al., Phys. Rev. C66, 044319 (2002)
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^{103}In: M. Karny et al., Nucl. Phys. A640, 3 (1998)
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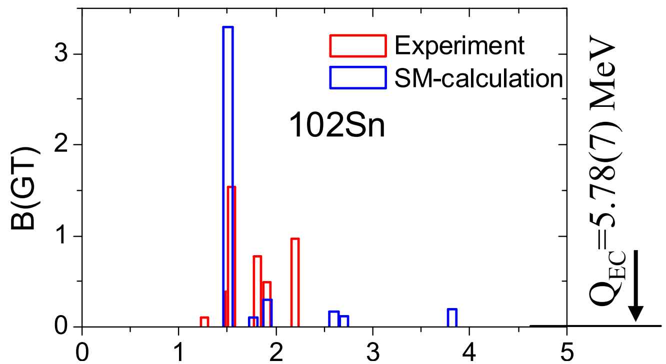
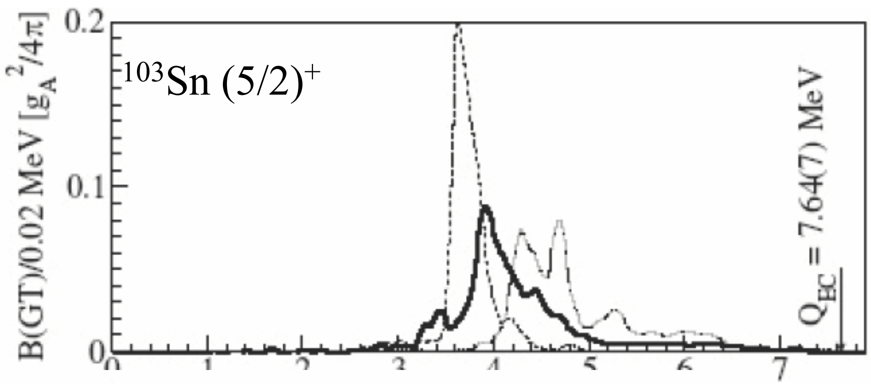
97,98Ag: Z. Hu et al., Phys. Rev. C60, 024315 (1999), C60, 064315 (2000)
^{100}Ag: L. Batist et al., Z.Phys. A351, 149 (1995)

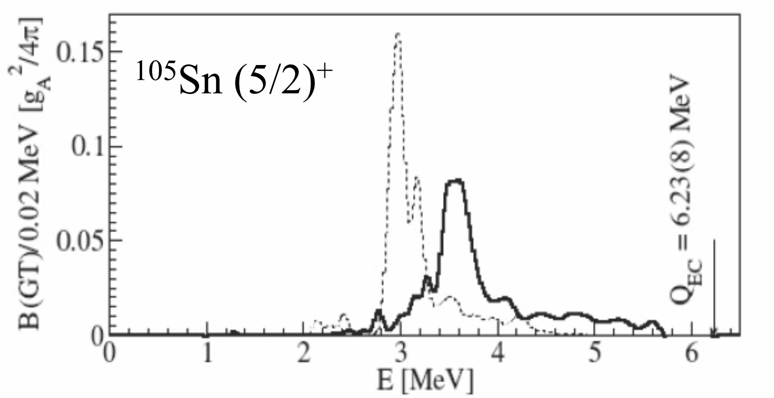
GT-strength distributions



M.arny et al., Eur. Phys. J. A27, 129 (2006)

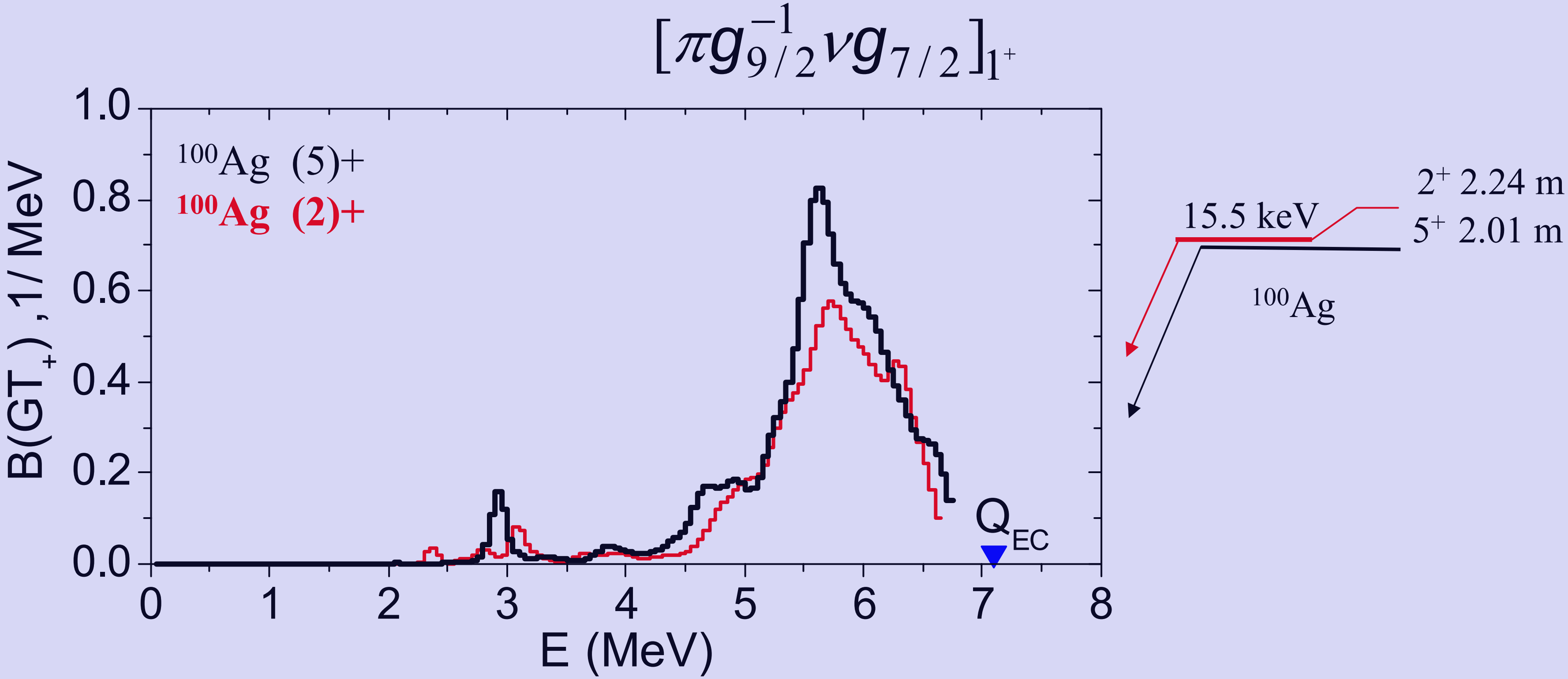


O. Kavatsyuk et al., Eur. Phys. J. A25, 211 (2005)



M. Kavatsyuk et al., Eur. Phys. J. A29, 183 (2005)

GT+ strength distributions ^{100}Ag-isomers

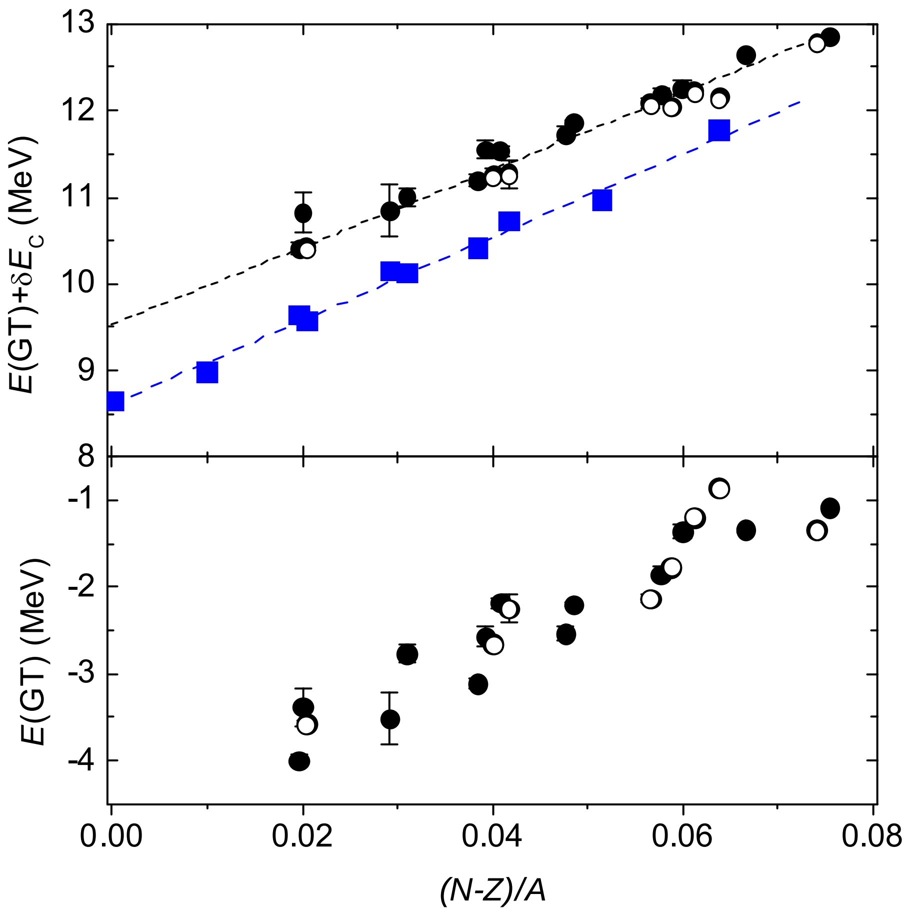


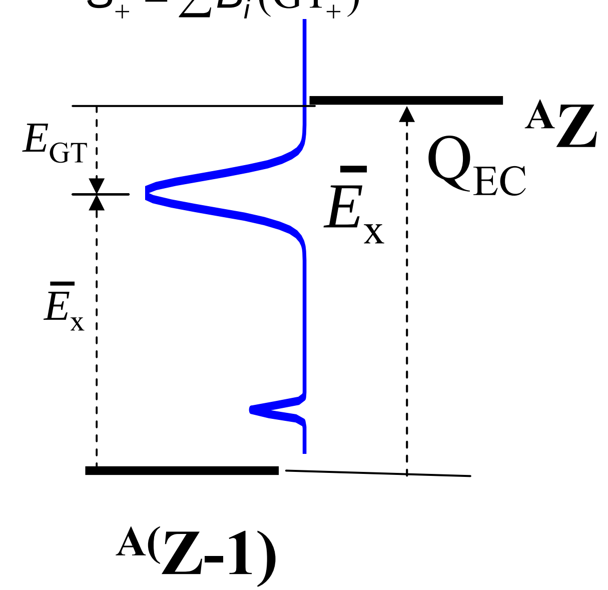
Energies of GT_+ states

$$E(\mathrm{GT}) \approx e_0 + e_1 \frac{N-Z}{A} - \delta E_{\mathrm{C}}$$

$$E_{\mathrm{GT}} = \sum (E_i - Q_{\mathrm{EC}}) \cdot B_i(\mathrm{GT}_+) / S_+$$

$$\delta E_{\mathrm{C}} \approx c \cdot Z / A^{1/3}\,\mathrm{MeV};\quad c = 1.36\,\mathrm{MeV}$$

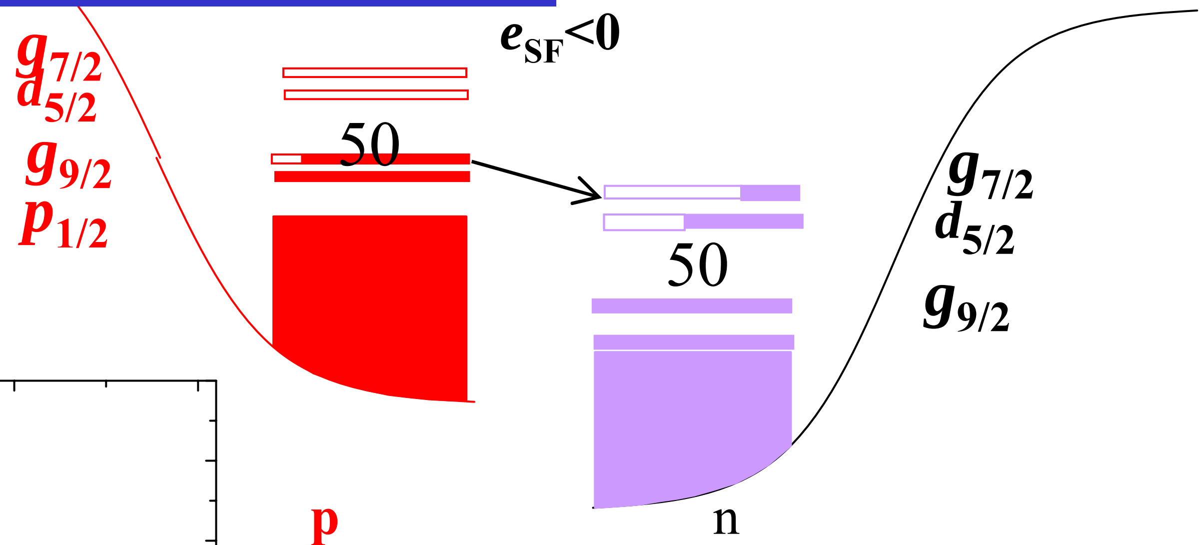


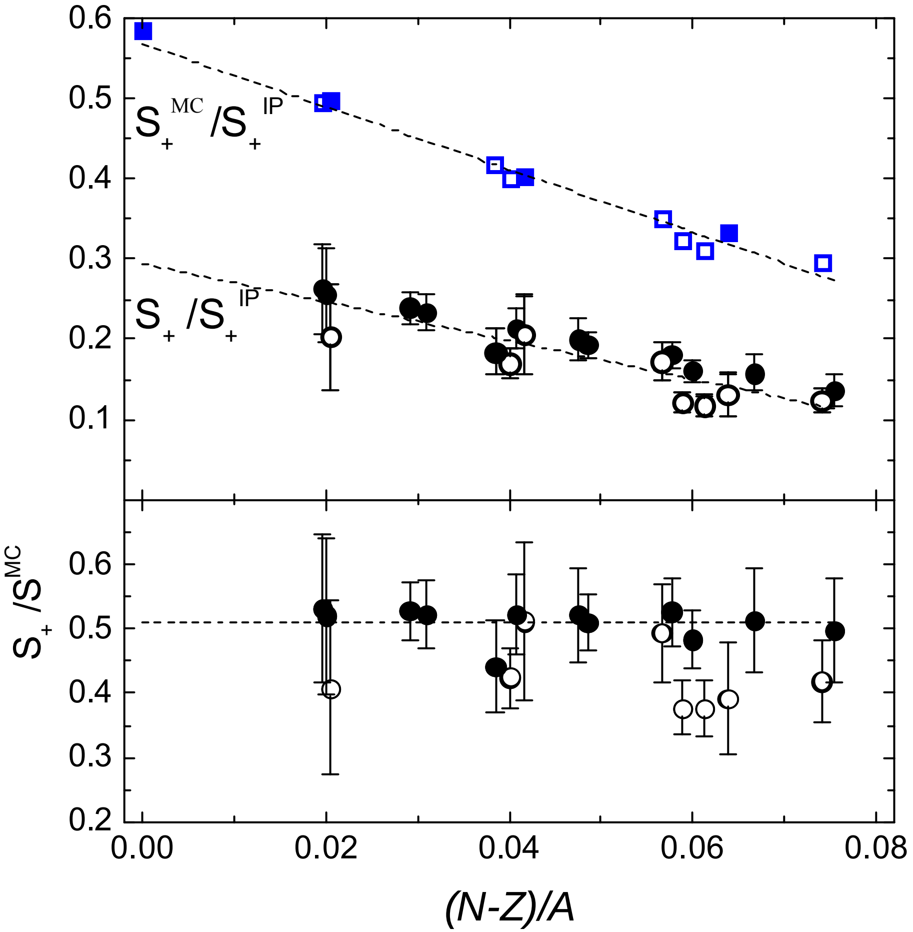


- ■ Shell Model
- ● TAS
- ○ high resolution

Summed GT$_+$ strength $S_+ = \Sigma B(GT_+)$

$\pi\, g_{9/2} \rightarrow \nu g_{7/2}$





$$S_+^{\mathrm{IP}} = b_{j_i j_f} \cdot n_{j_i} \cdot \left(1 - \frac{n_{j_f}}{(2 j_f + 1)}\right) \approx$$

$$\frac{160}{9} \frac{(Z - Z_0)}{(50 - Z_0)} \frac{(N_0 - N)}{(N_0 - 50)},$$

$$b_{9/2,7/2} = 16/9; Z_0 = 39.6; N_0 = 69$$

■ SM Monte Carlo

□ RPA fit

● TAS

○ high resolution

quenching

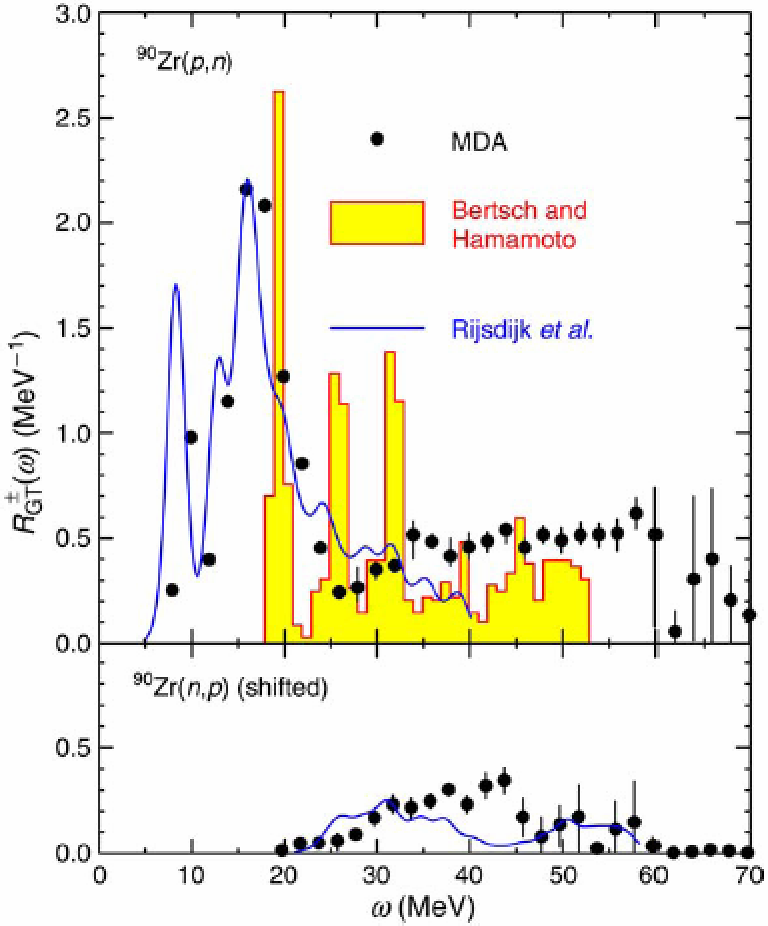
	valence shell	Z	q	ref
β_+	*p*	$Z < 8$	0.672(24)	[1]
β_+	*sd*	$8 \leq Z \leq 14$	0.59(3)	[2]
β_+, β_-	*pf*	$21 \leq Z \leq 23$	0.554(22)	[3]
β_+	**g**	$44 \leq Z \leq 50$	**0.507(20)**	**this work**
GTR				
(β_-, β_+)	g	^{90}Zr	0.65	[4,5].
(β_-)	gdh	$^{112-124}Sn$	0.65(3)	[6]

S_{res}/S_{calc}

$S_{res}/3(N\text{-}Z)$

1. B. H. Wildenthol et al., Phys. Rev. C28, 1343,(1983)
2. E. Caurier et al., Phys. Rev. C50, 225 (1994)
3. G. Martınez-Pinedo et al., Phys. Rev. C **53**. R2602 (1996)
4. T. Wakasa et al., Phys. Rev. C **55**, 2909 (1997).
5. K. Yako et al., Phys. Lett. B 615 (2005) 193.
6. K. Pham et al., Phys. Rev. **51**, 426 (1995)

p,n and n,p reaction on ^{90}Zr



$$\frac{S_{-}-S_{+}}{3(N-Z)} = 0.86 \pm 0.07$$

$$q = \frac{S_{-}^{res}}{3(N-Z)} = 0.65$$

GT− (top panel) and GT+ (bottom panel) strength distributions (filled circles) obtained from the $L = 0$ cross sections deduced from the MDA.

from M. Ichimuraa et al., Progress in Part. Nucl. Phys. 56, 446 (2006)

$$(S_- - S_+)_{\mathrm{N}} = 3(N - Z)$$

$$\frac{B(GT_+)_{n\to\Delta^-}}{B(GT_-)_{n\to\Delta^+}} = \frac{B(GT_-)_{p\to\Delta^{++}}}{B(GT_+)_{p\to\Delta^0}} = 3$$

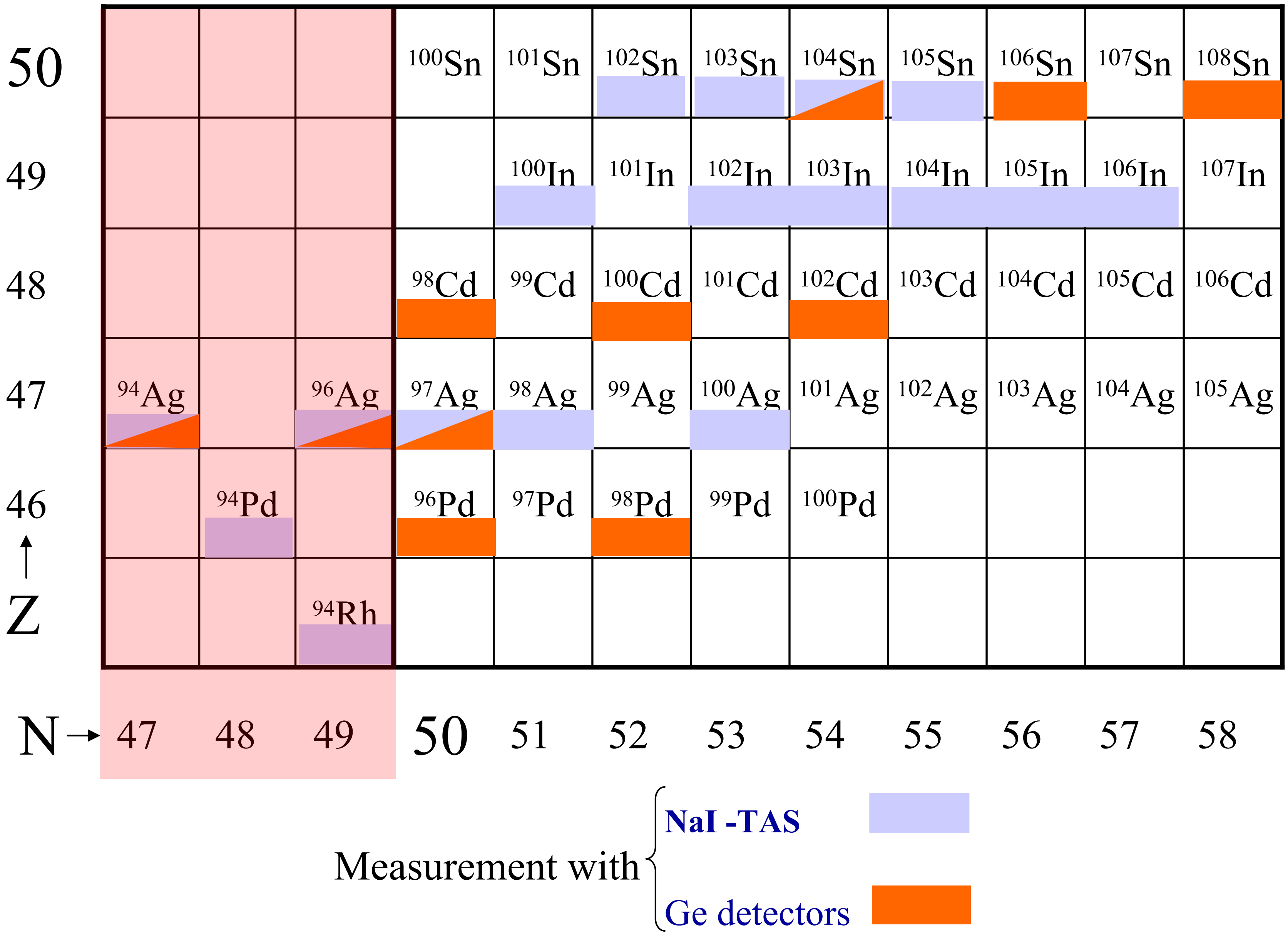
$$(S_- - S_+)_{\Delta+\mathrm{N}} = 0.36\cdot 3(N - Z)$$

. Properties of ^{100}Sn and ^{101}Sn derived from

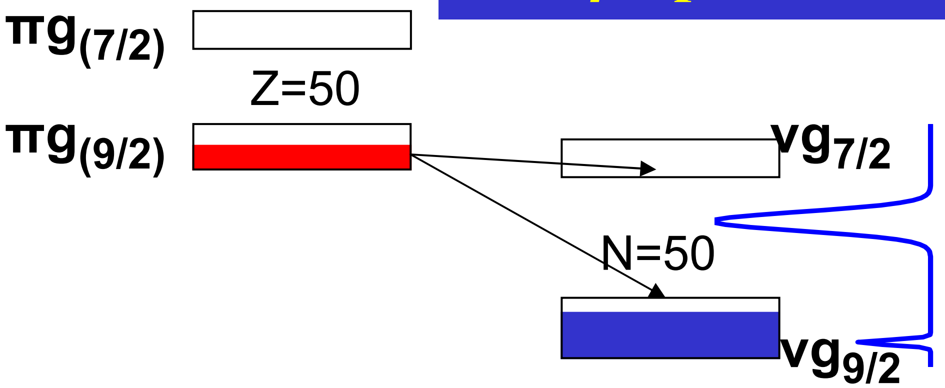
the extrapolation of systematics

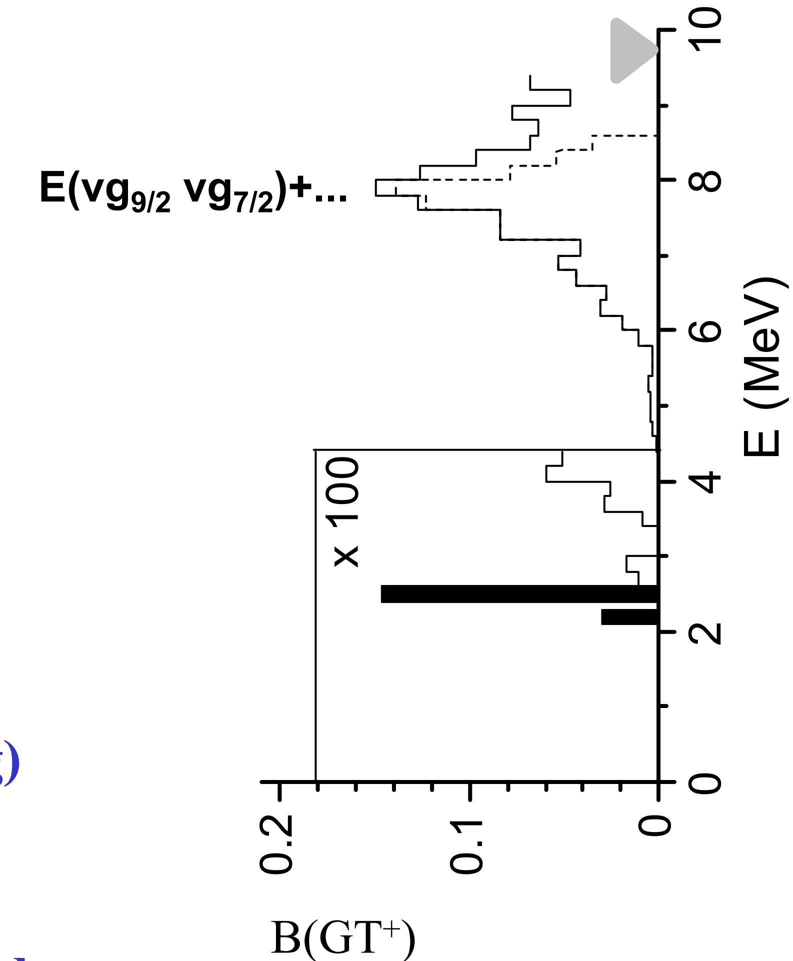
		100Sn	101Sn	
			5/2$^+$	7/2$^+$
E(GT) (MeV)		-4.95(11)	-4.45(11)	
B(GT)		5.40(74)	4.75(66)	
$t_{1/2}$ (s)		**0.92(18)**	**1.76(30)**	**1.58(30)**
$t_{1/2}$ (s) exp		**1.0** $^{+0.54}_{-0.26}$	**1.9(3)**	
E_X (MeV)	SM	2.23	4.09	4.39
Q_{EC} (MeV)		7.18	8.54	8.84
Q_{EC} (MeV)	syst	7.390	9.054	

Crossing a border N<50



N < 50
β+ распад ^{94}Pd и ^{94}Rh

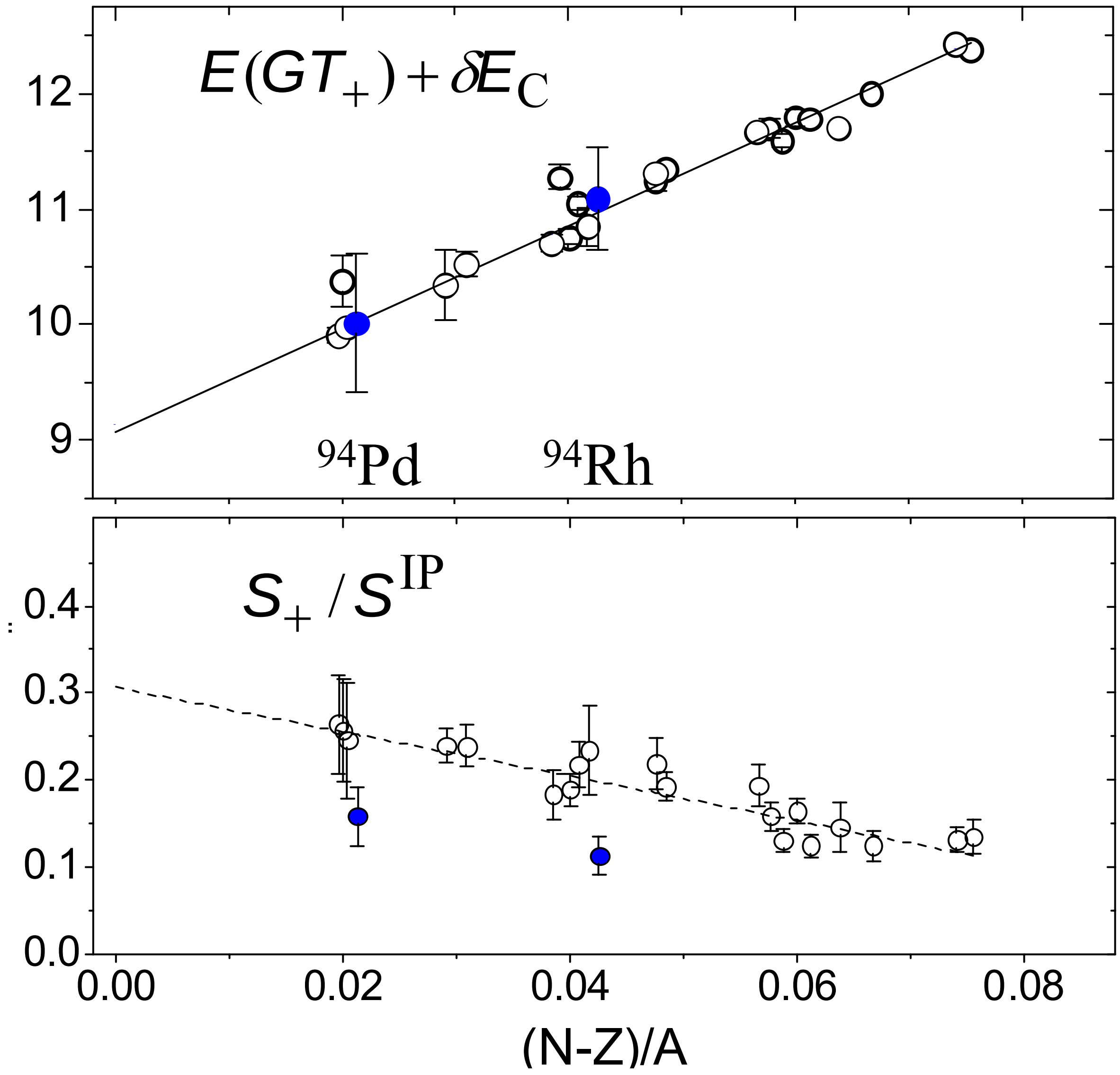




$\pi g9/2 \rightarrow \nu g9/2$ and $\pi g9/2 \rightarrow \nu g7/2$ separated by the $\nu g_{9/2}$ to $\nu g_{7/2}$ transition energy (≈ spin-orbit splitting)

- **Two branches of bare Gamow-Teller strength**
- **Both groups of final states are expected to be within Q_{EC}-window.**

N<50



$E(GT_+) + \delta E_C$
12
11
10
9
^{94}Pd
^{94}Rh
S_+ / S^{IP}
0.4
0.3
0.2
0.1
0.0
0.00
0.02
0.04
0.06
0.08
(N-Z)/A