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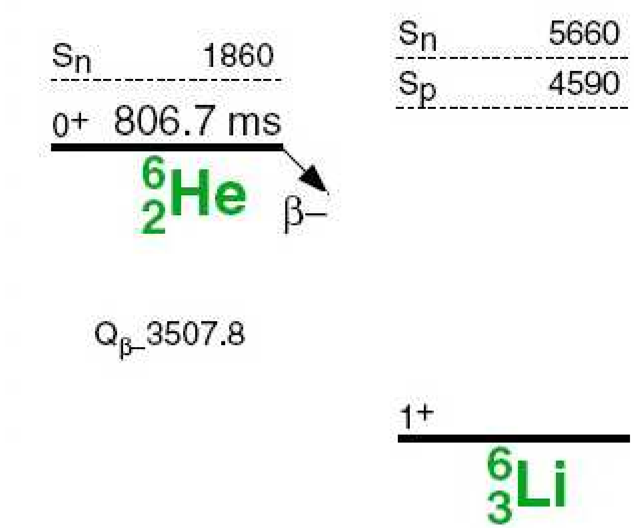
# Gamow-Teller strength as a probe of proton-neutron pairing

# Examples of GT transitions with large B(GT)



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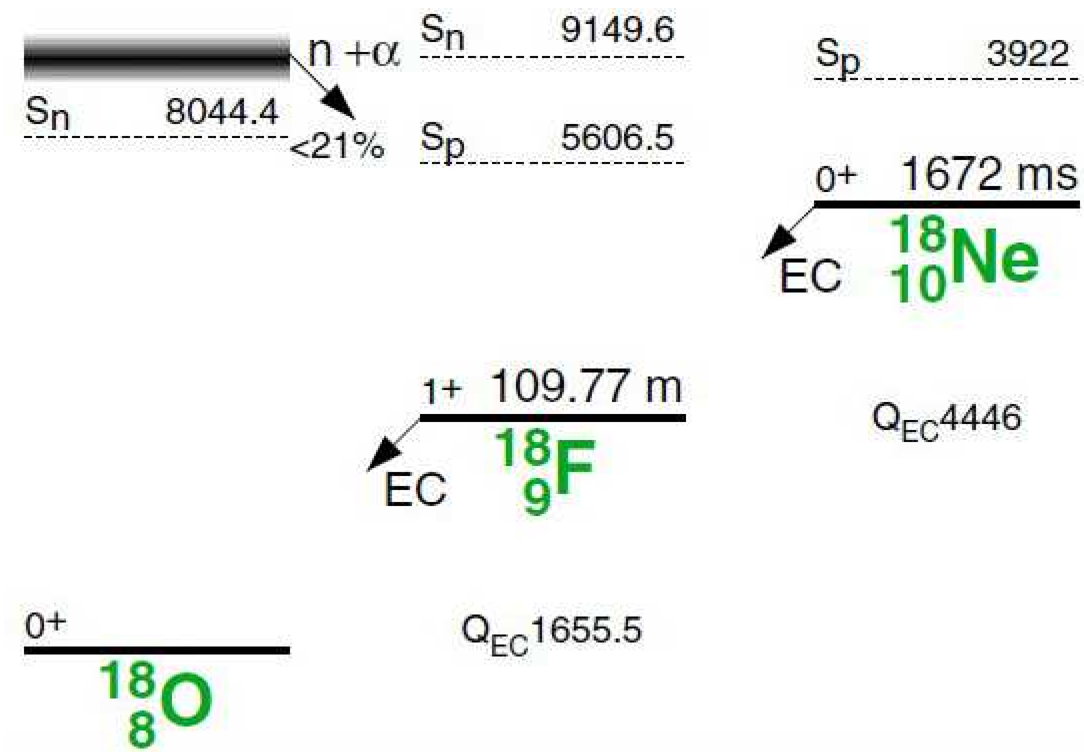


# Examples of transitions with large B(GT) and B(M1)

## B(GT)

Table 1: Strong GT between low-lying states

| $0^+$ T=1 | $1^+$ T=0 | experiment | $0\hbar\omega$ | R(exp/$0\hbar\omega$) | GFMC | R(GFMC/$0\hbar\omega$) |
|---|---|---|---|---|---|---|
| $^{6}$He | $^{6}$Li | 4.72(2) | 5.54 | 0.85 | 4.65 | 0.84 |
| $^{18}$Ne | $^{18}$F | 3.146(23) | 5.06 | 0.62 | | |
| $^{18}$O | $^{18}$F | 3.118(11) | 5.06 | 0.62 | | |
| $^{42}$Ti | $^{42}$Sc | 2.14(6) | 4.20 | 0.51 | | |

GT quenching

## B(M1)

Table 2: Strong M1 between low-lying states

| $0^+$ T=1 | $1^+$ T=0 | experiment $\mu_N^2$ | $0\hbar\omega$ $\mu_N^2$ | R(exp/$0\hbar\omega$) | GFMC $\mu_N^2$ | R(GFMC/$0\hbar\omega$) |
|---|---|---|---|---|---|---|
| $^{6}$Li | $^{6}$Li | 15.6(3) | 15.0 | 1.04(2) | 13.1 | 0.87 |
| $^{18}$F | $^{18}$F | 19.7(35) | 16.4 | 1.20(21) | | |
| $^{42}$Sc | $^{42}$Sc | 19(10) | 22.0 | 0.8(4) | | |

Is the $B(GT)$ an observable?

$$B(GT) = |< \Psi_f \mid O(GT) \mid \Psi_i >|^2$$

$$O(GT) = \vec{\sigma}\tau_{\pm} \quad \Delta S = 1 \quad \Delta T = 1$$

$$< \Psi_f \mid O(GT) \mid \Psi_i > = \sum_{\alpha,\beta} < \Psi_f \mid a^+_\alpha a_\beta \mid \Psi_i >< \alpha \mid O(GT) \mid \beta >$$

Calculation with GFMC

$$< \Psi_f \mid O(GT) \mid \Psi_i >$$

agrees with experiment in light nuclei.

Calculation in a truncated space

$$< \tilde{\Psi}_f \mid O(GT) \mid \tilde{\Psi}_i >$$

when compared with experiment requires quenching.

To understand the quenching one needs to evaluate the effective operator for the finite model space which includes an SRG $\Lambda$-dependent truncation

$$< \tilde{\Phi}_f \mid \tilde{O}(GT) \mid \tilde{\Phi}_i > .$$

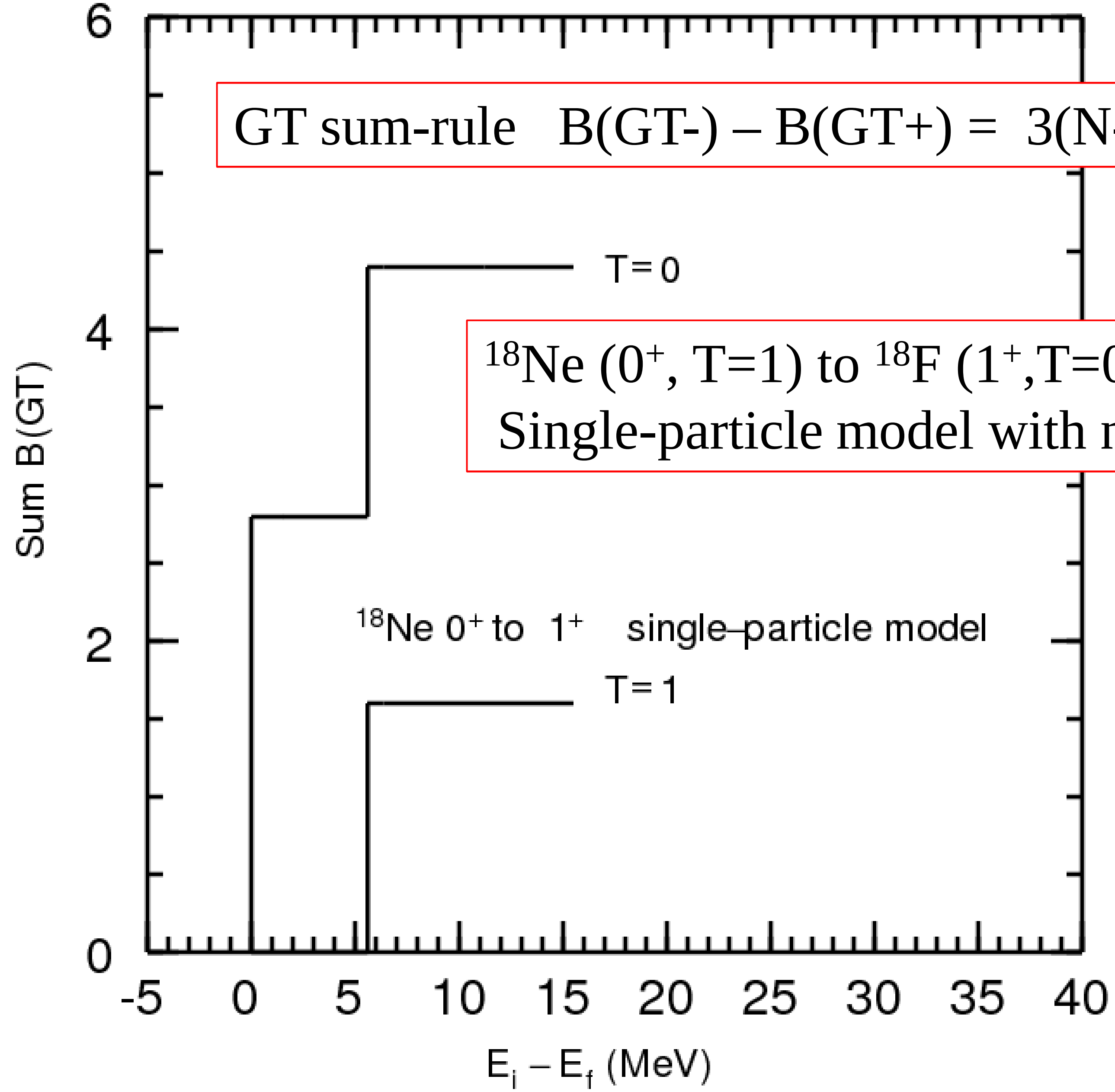
Done in the 1980's but needs to be redone with modern methods. This in principle requires effective two-body GT operators – but in practice an effective one-body operator may be sufficient.

Is the "quenching" of $B(GT)$ connected to the quenching one one-nucleon spectroscopic factors.

For charge exchange reactions we need the radial overlap function $F(r)$ associated with $O(GT)$.

GT sum-rule B(GT-) – B(GT+) = 3(N-Z) = 6

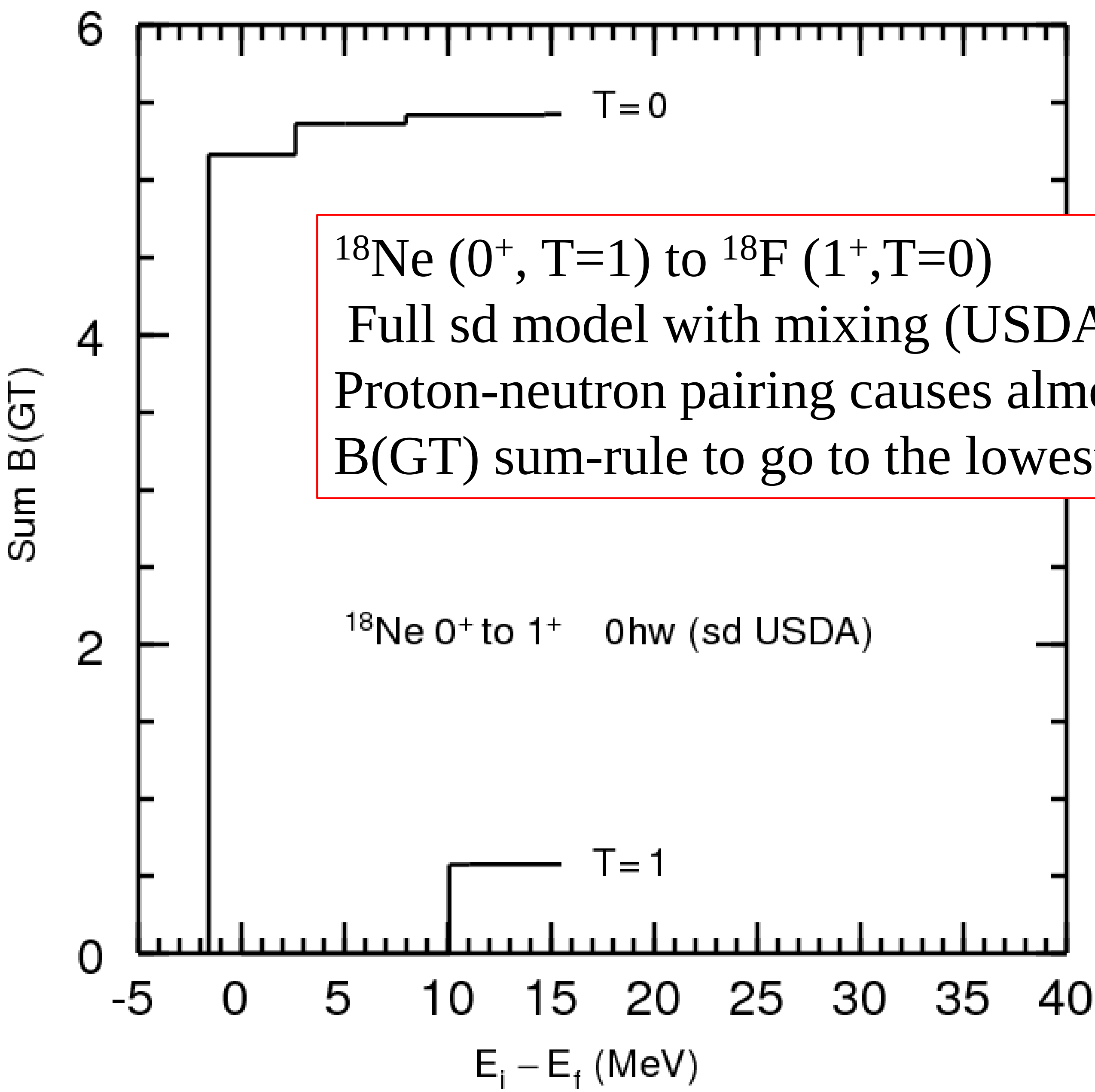
$^{18}$Ne ($0^+$, T=1) to $^{18}$F ($1^+$,T=0)
Single-particle model with no mixing



$^{18}$Ne ($0^+$, T=1) to $^{18}$F ($1^+$,T=0)

Full sd model with mixing (USDA)

Proton-neutron pairing causes almost all of B(GT) sum-rule to go to the lowest $1^+$ state



Typical sd-shell results for A=18

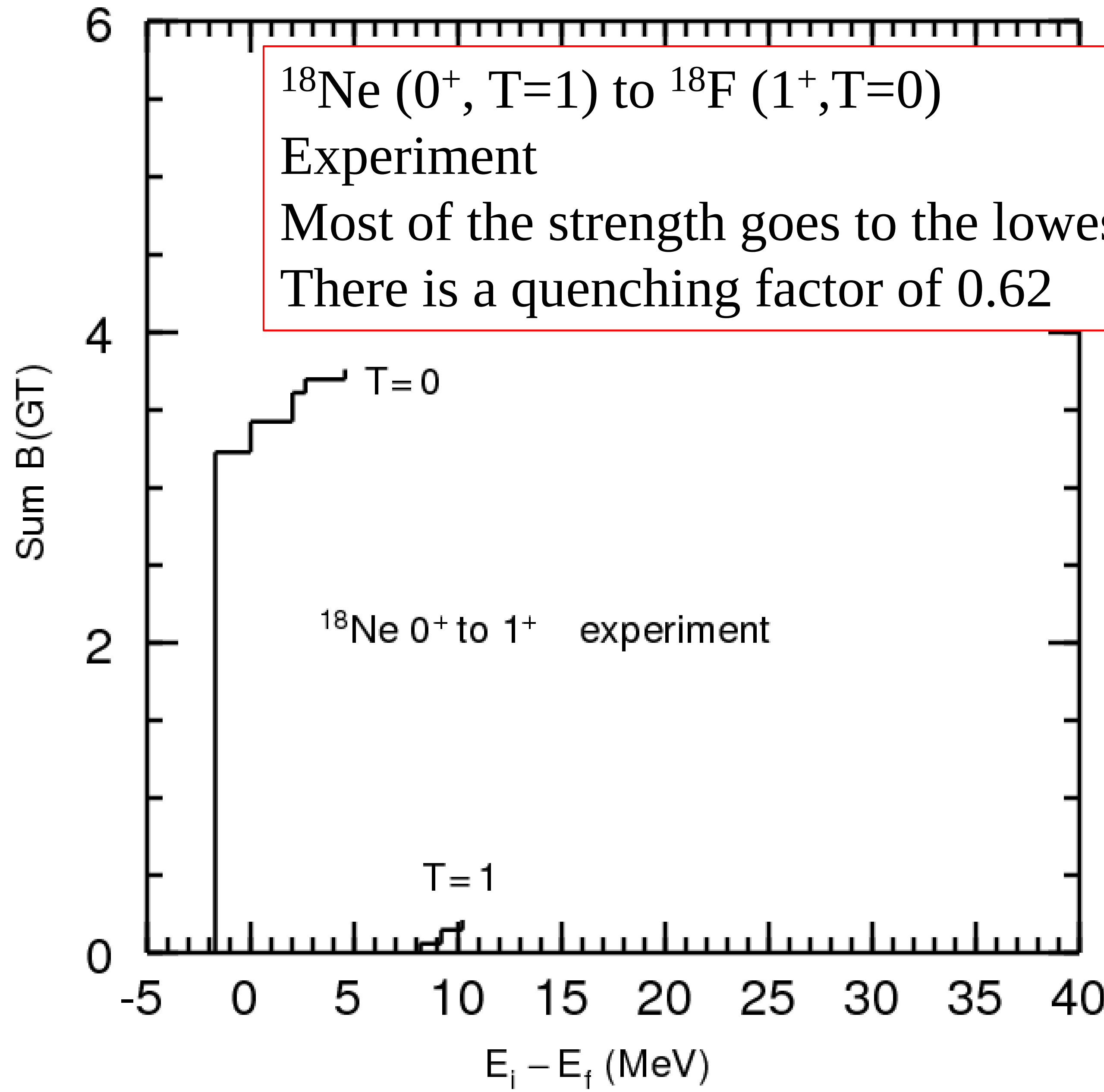
| | | |
|---|---|---|
| 0+ T=1 | 79.9 % (d5/2)^2 | 86.1 % L=0, S=0 |
| 1+ T=0 | 28.6 % (d5/2)^2 | 90.6 % L=0, S=1 |

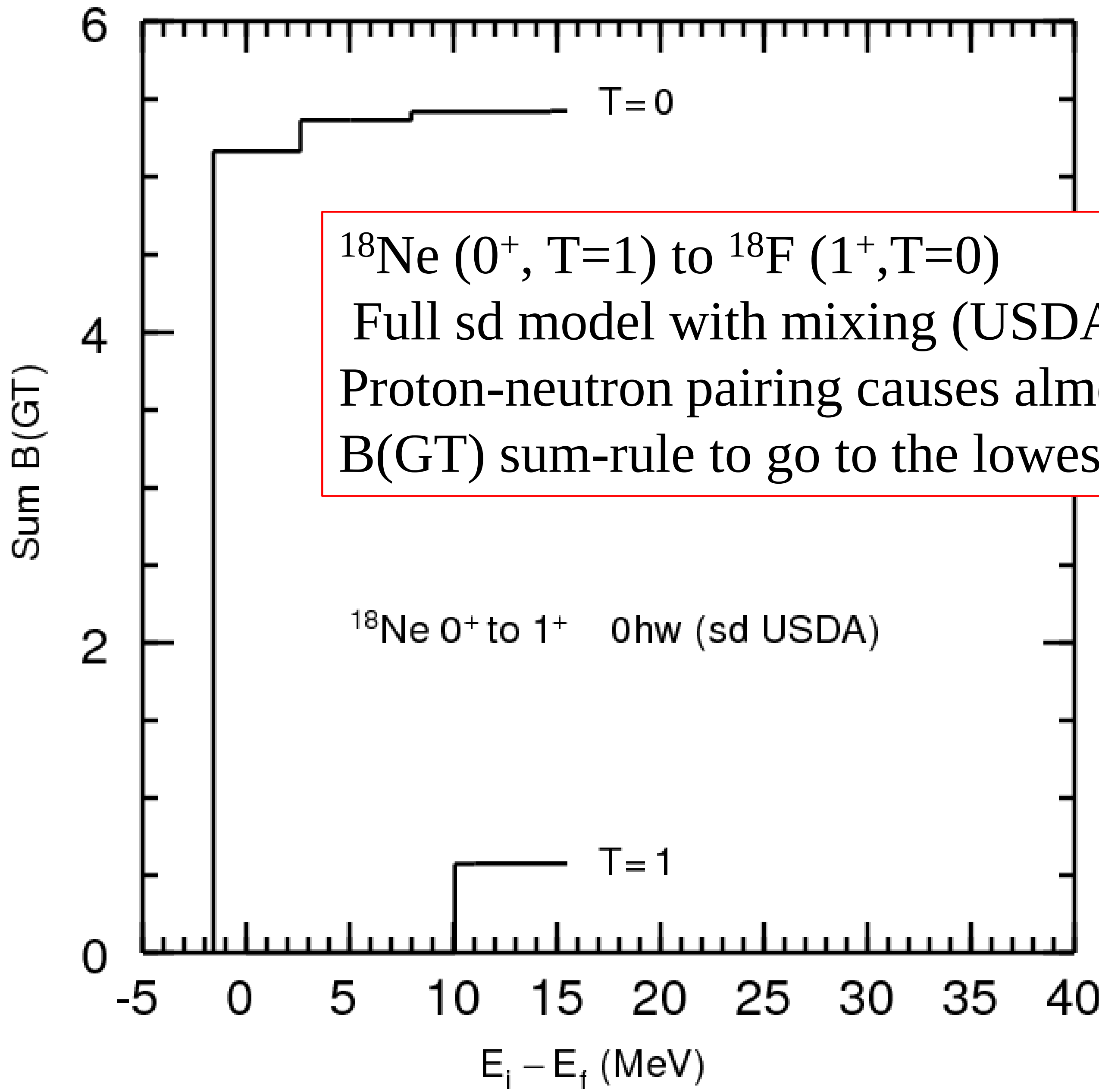
$^{18}$Ne ($0^+$, T=1) to $^{18}$F ($1^+$,T=0)

Experiment

Most of the strength goes to the lowest $1^+$

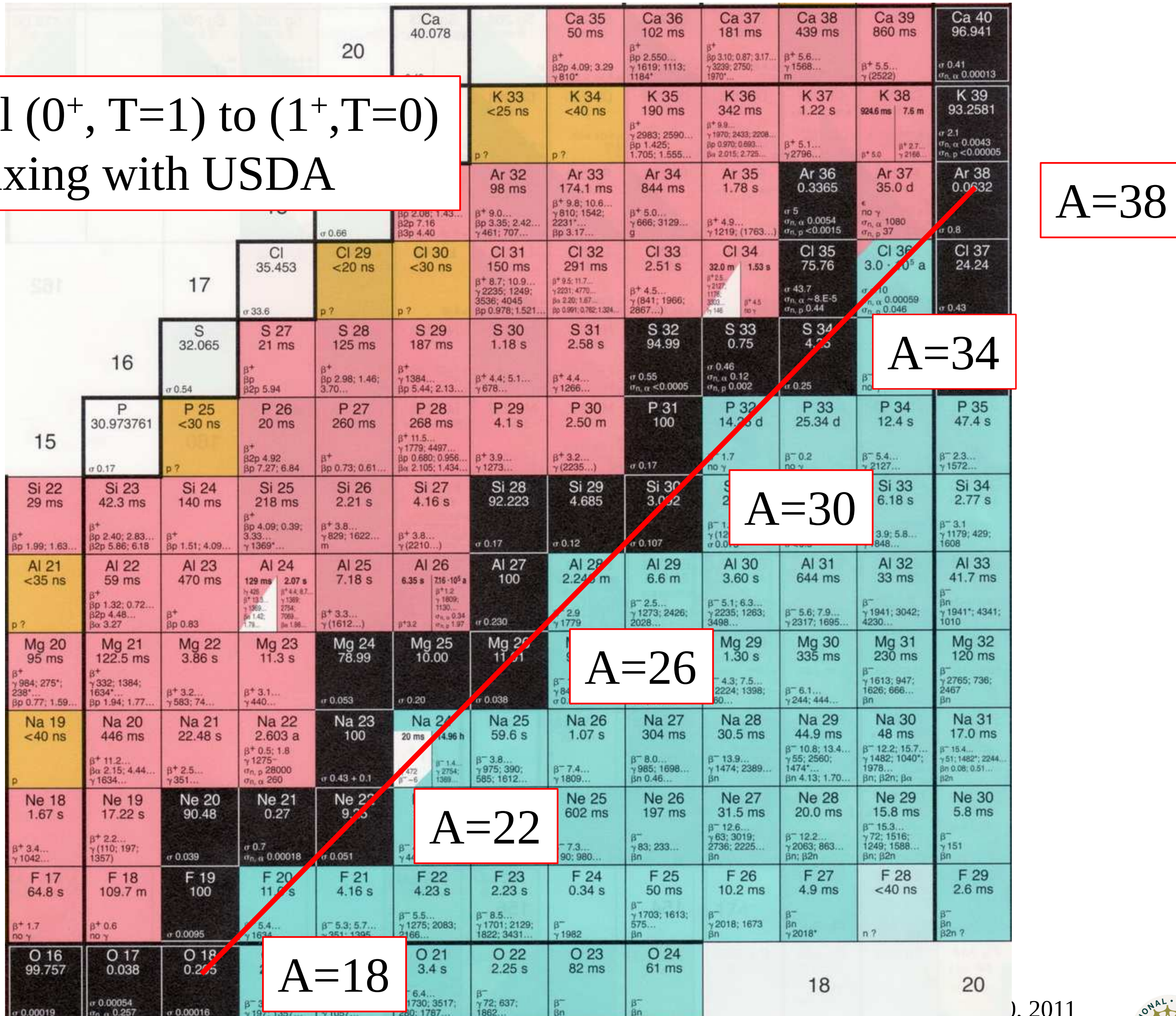
There is a quenching factor of 0.62





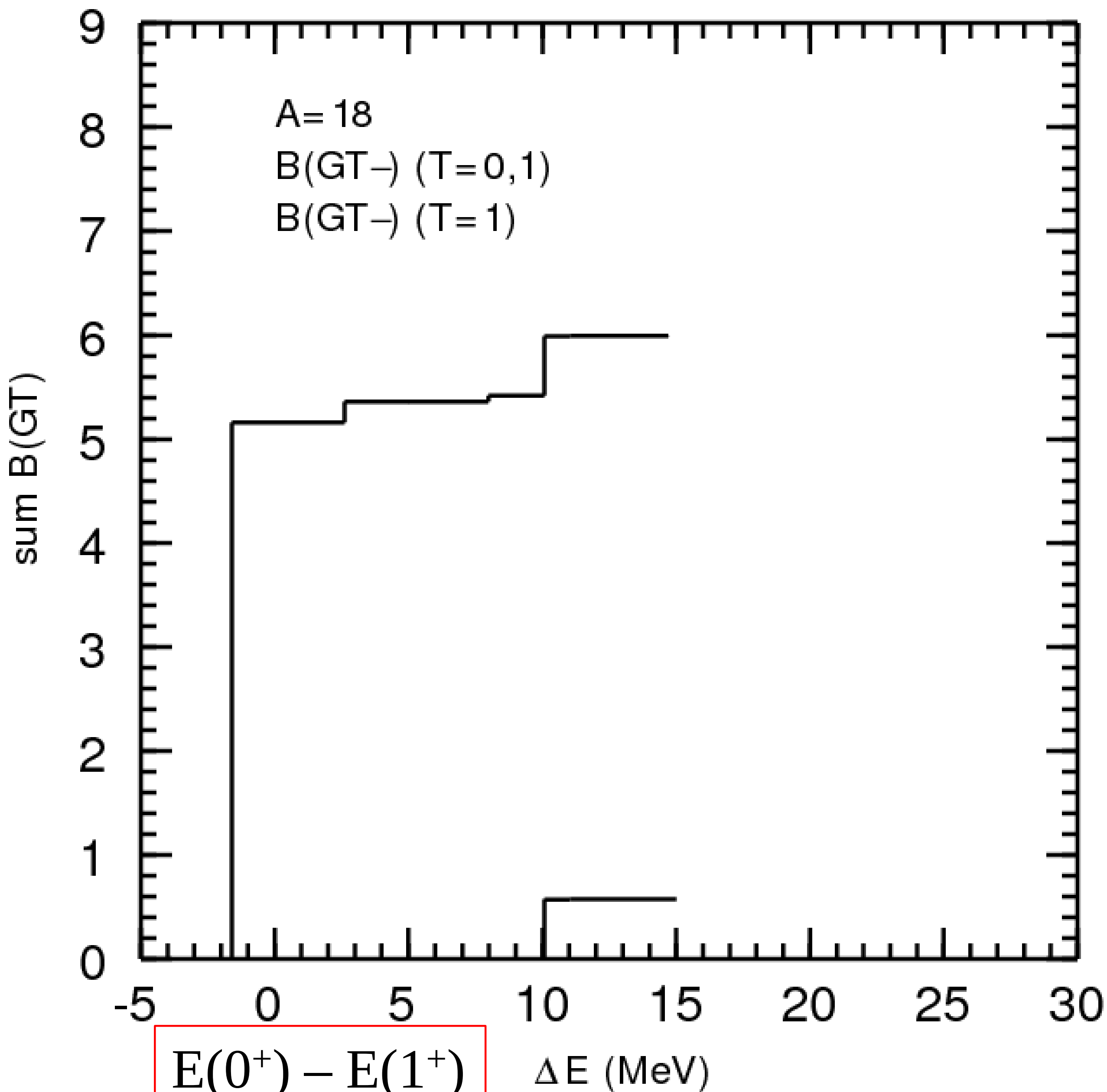

$^{18}$Ne ($0^{+}$, T=1) to $^{18}$F ($1^{+}$,T=0)
Full sd model with mixing (USDA)
Proton-neutron pairing causes almost all of B(GT) sum-rule to go to the lowest $1^{+}$ state

sd-shell ($0^+$, T=1) to ($1^+$,T=0)
Full mixing with USDA

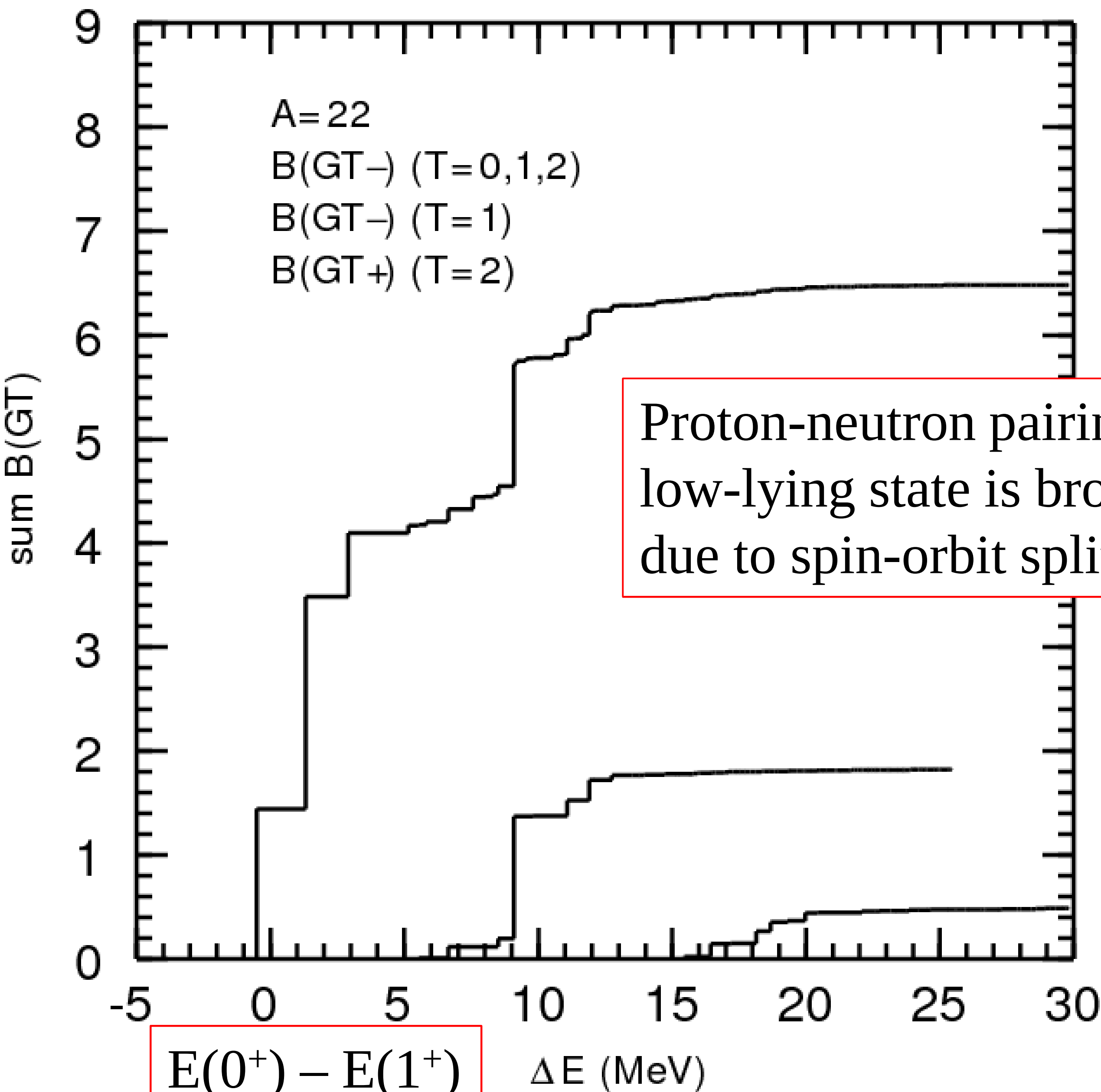





NSCL

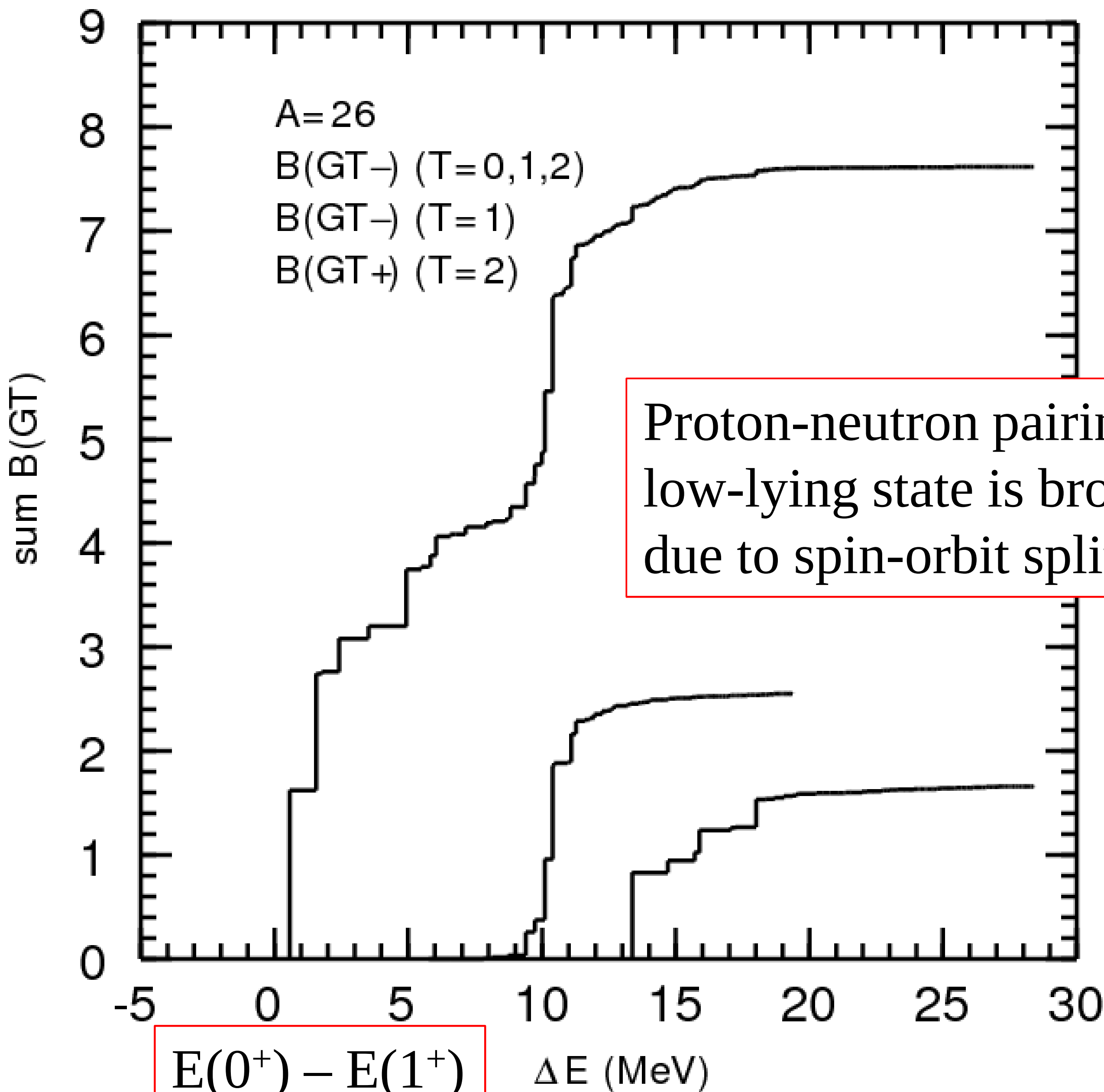



$E(0^+) - E(1^+)$




Proton-neutron pairing for the low-lying state is broken due to spin-orbit splitting

$E(0^{+}) - E(1^{+})$

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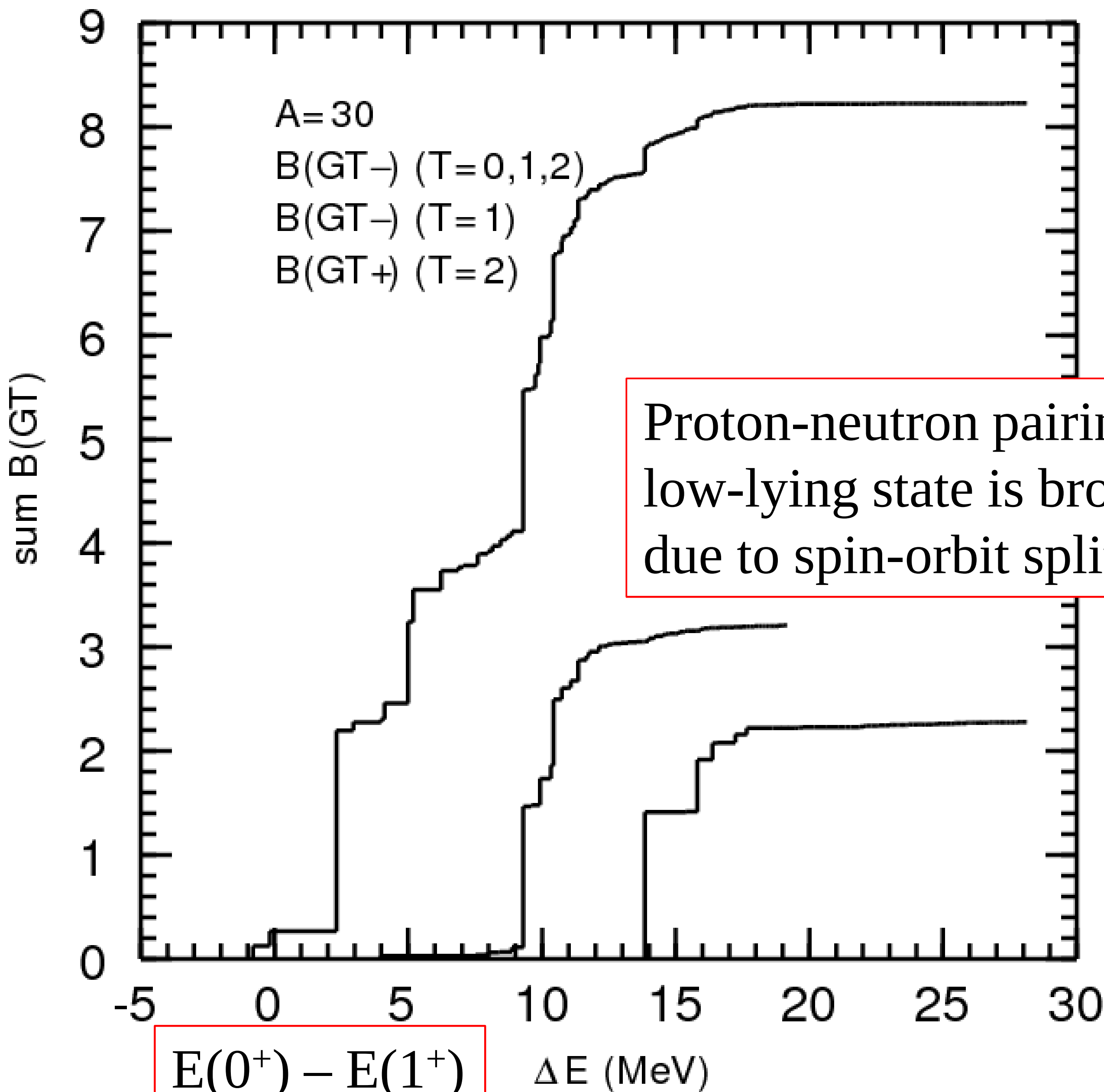


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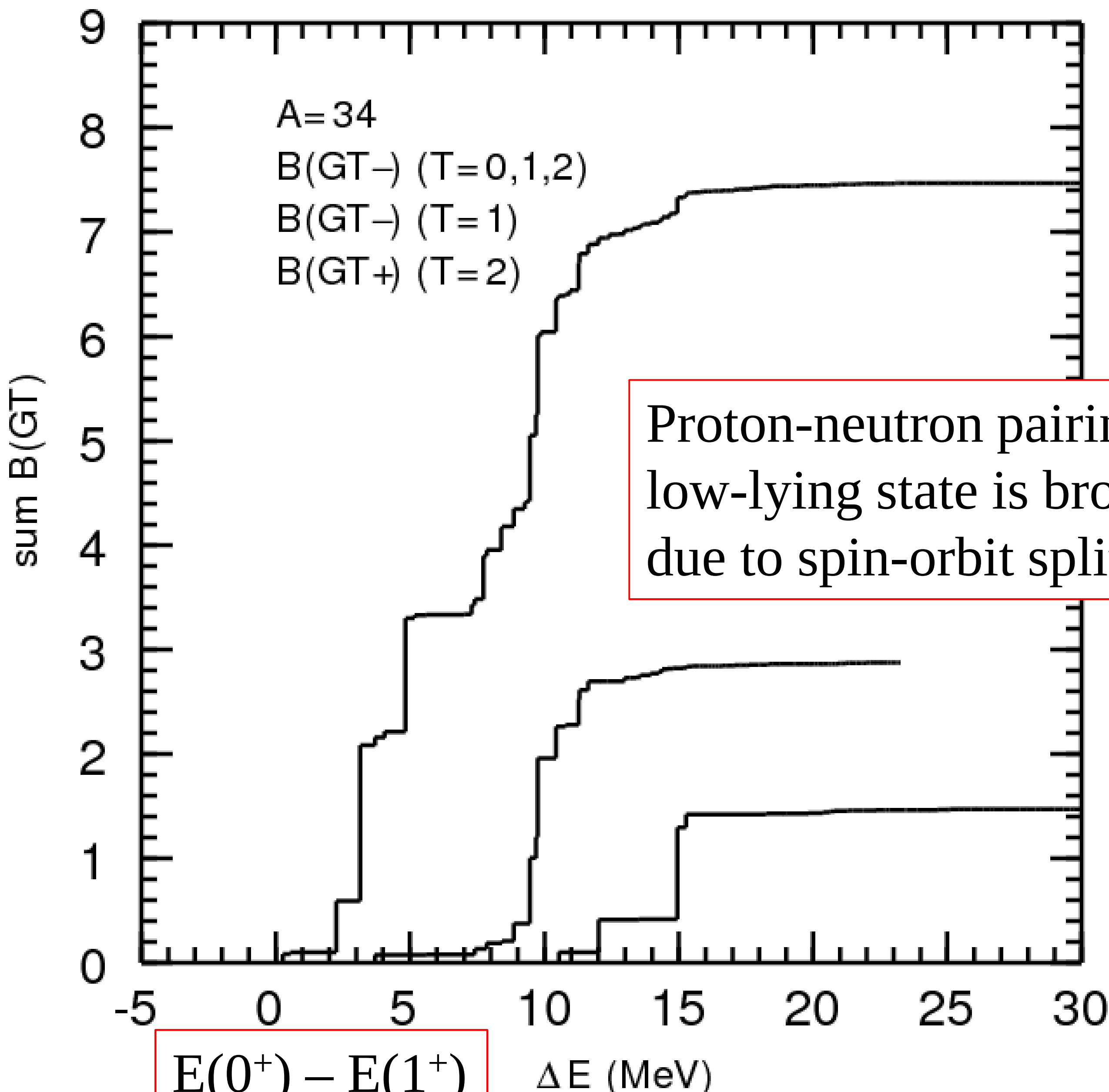


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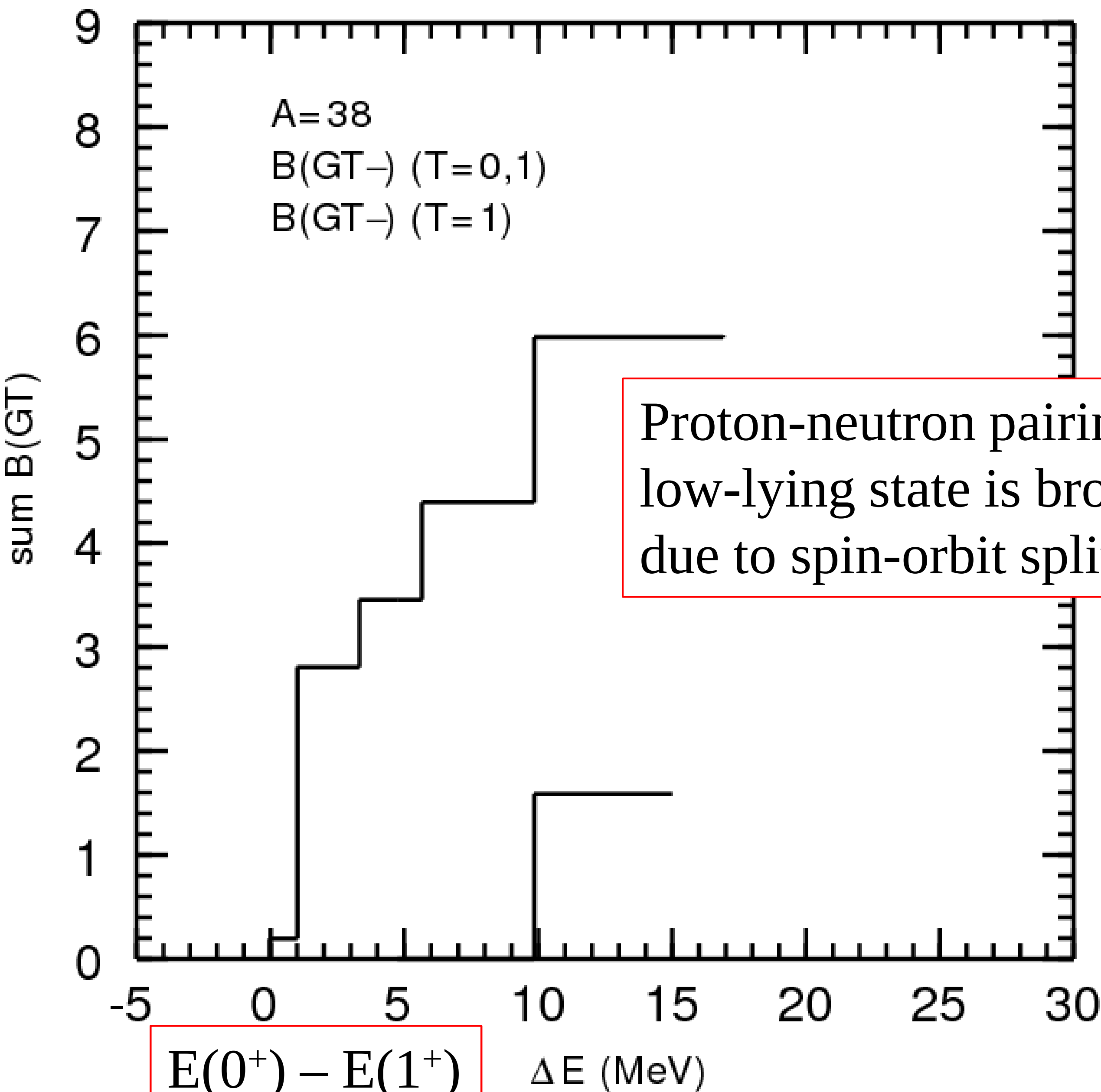


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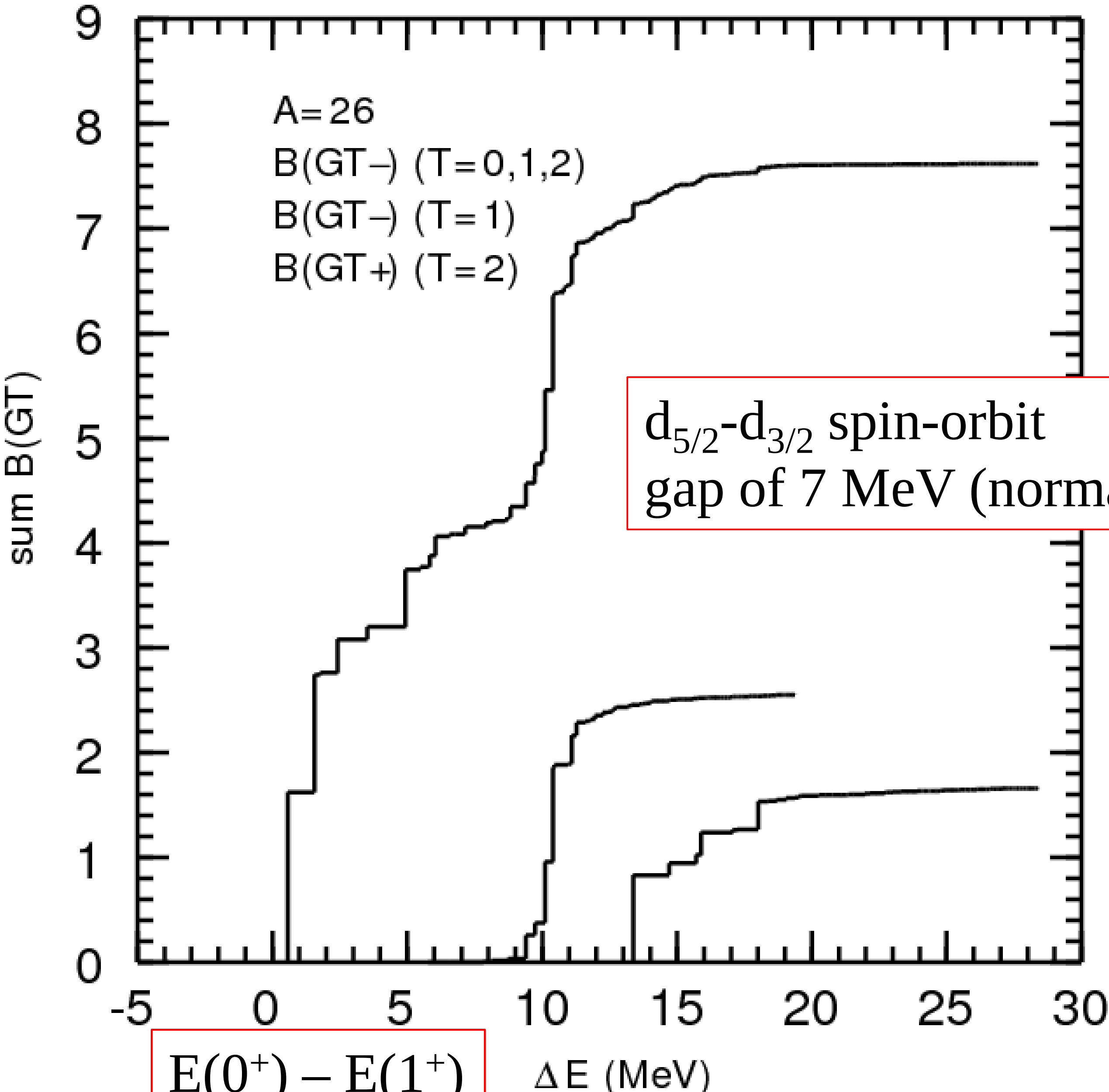
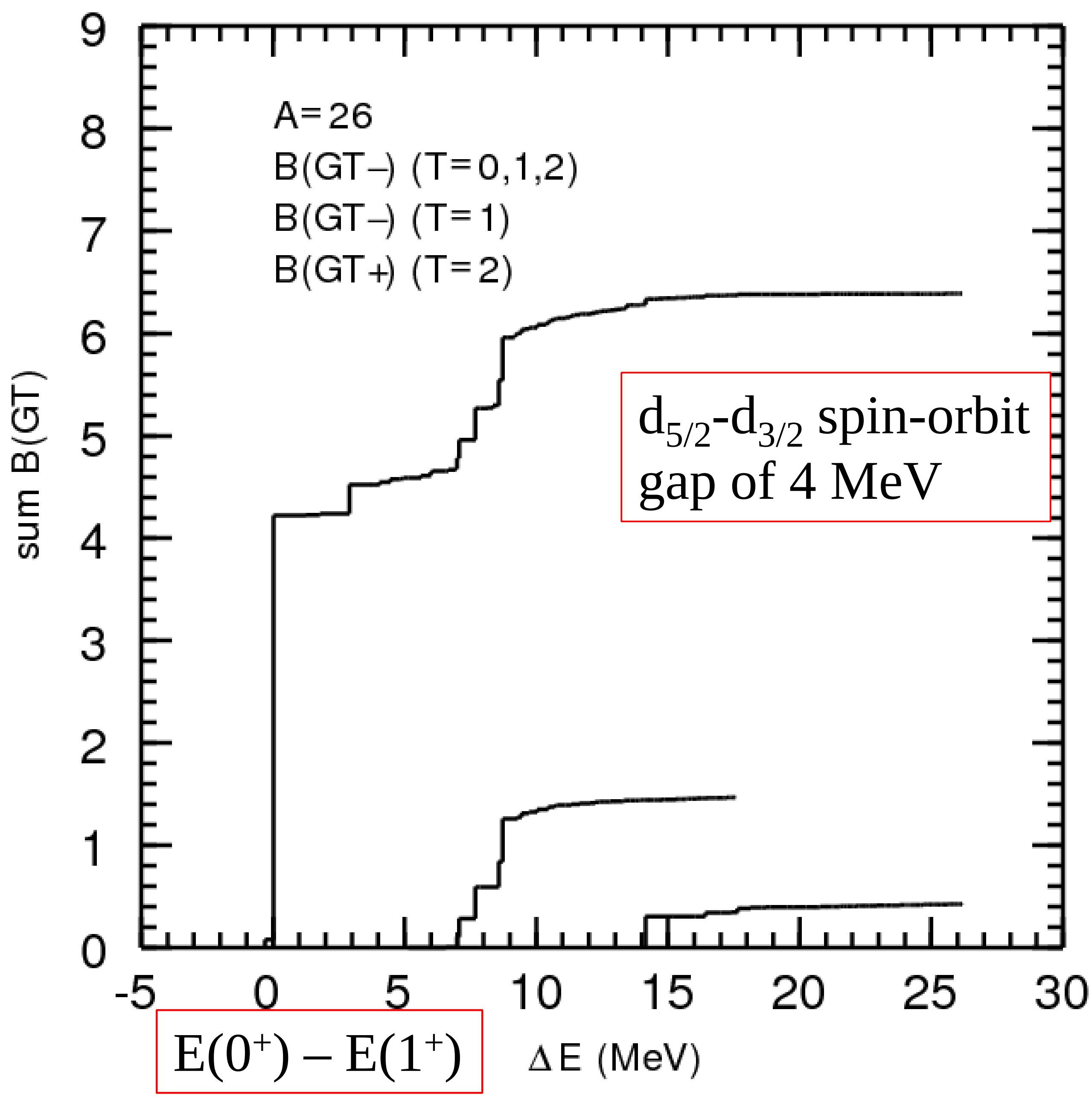


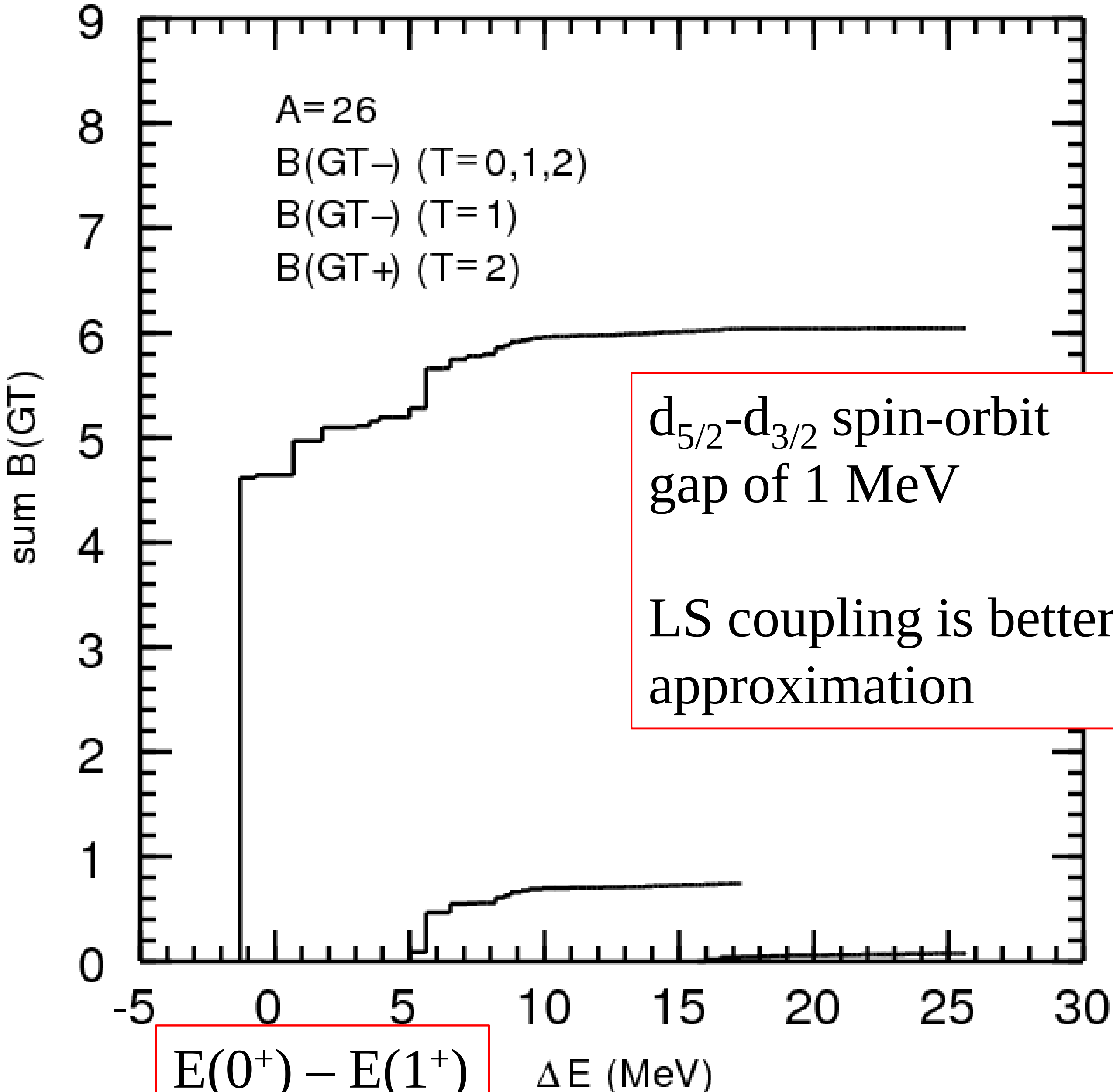

$d_{5/2}$-$d_{3/2}$ spin-orbit gap of 7 MeV (normal)

$E(0^+) – E(1^+)$




$d_{5/2}$-$d_{3/2}$ spin-orbit gap of 4 MeV

$E(0^+) - E(1^+)$




$d_{5/2}$-$d_{3/2}$ spin-orbit gap of 1 MeV

LS coupling is better approximation

$E(0^+) - E(1^+)$