$\Delta K = 1$ Coriolis mixing of 1^+ states of ^{164}Dy

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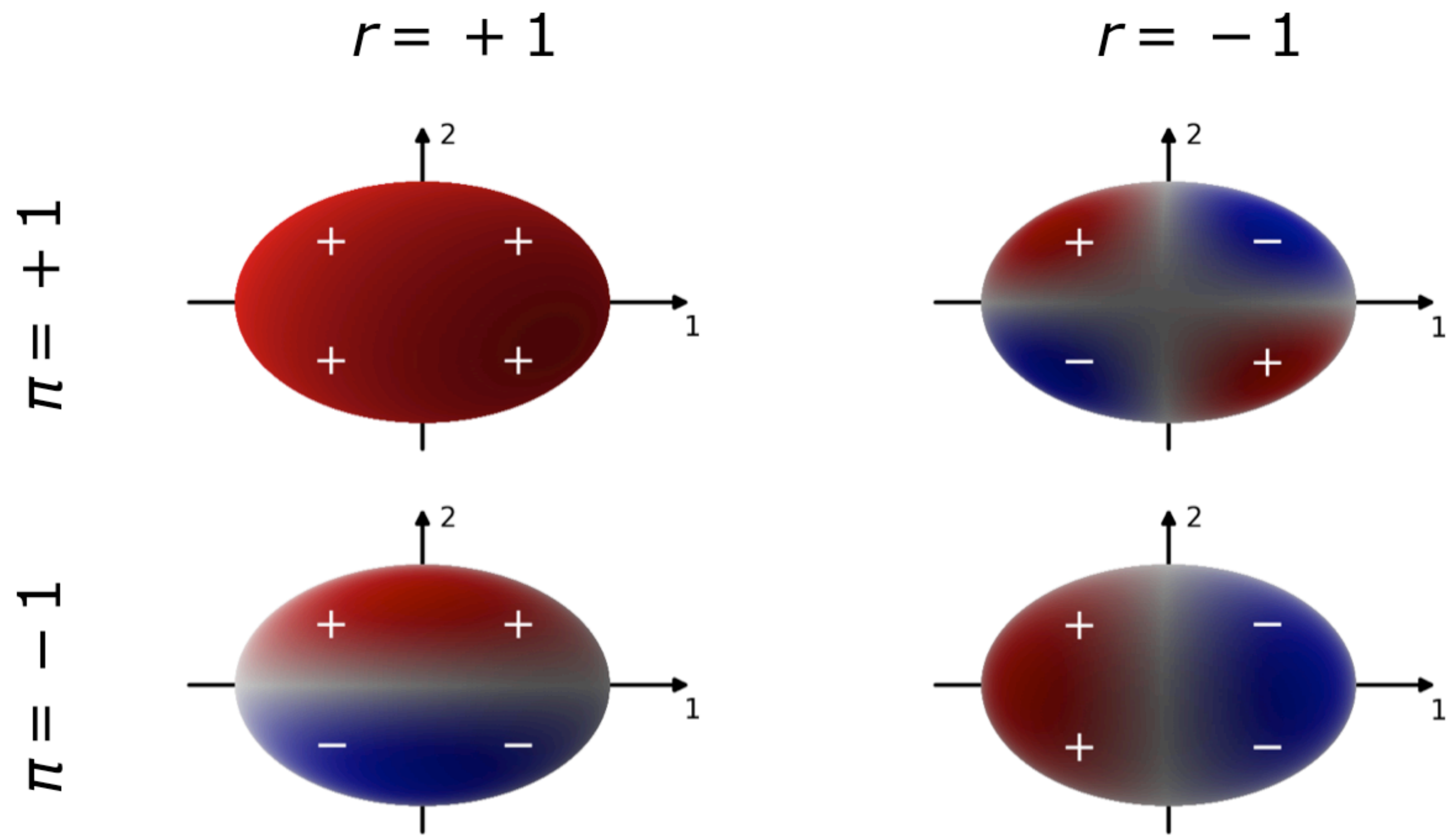
Symmetries of quantum systems

Commonly encountered symmetries of nuclei are axially-symmetric deformation and space-reflection invariance. In combination, both yield a spheroidal nuclear shape.

Alternative: $\mathscr{R}$ symmetry ($r = \pm 1$)

Bohr and Mottelson, Nuclear Structure II, W.A. Benjamin Inc. (1975)



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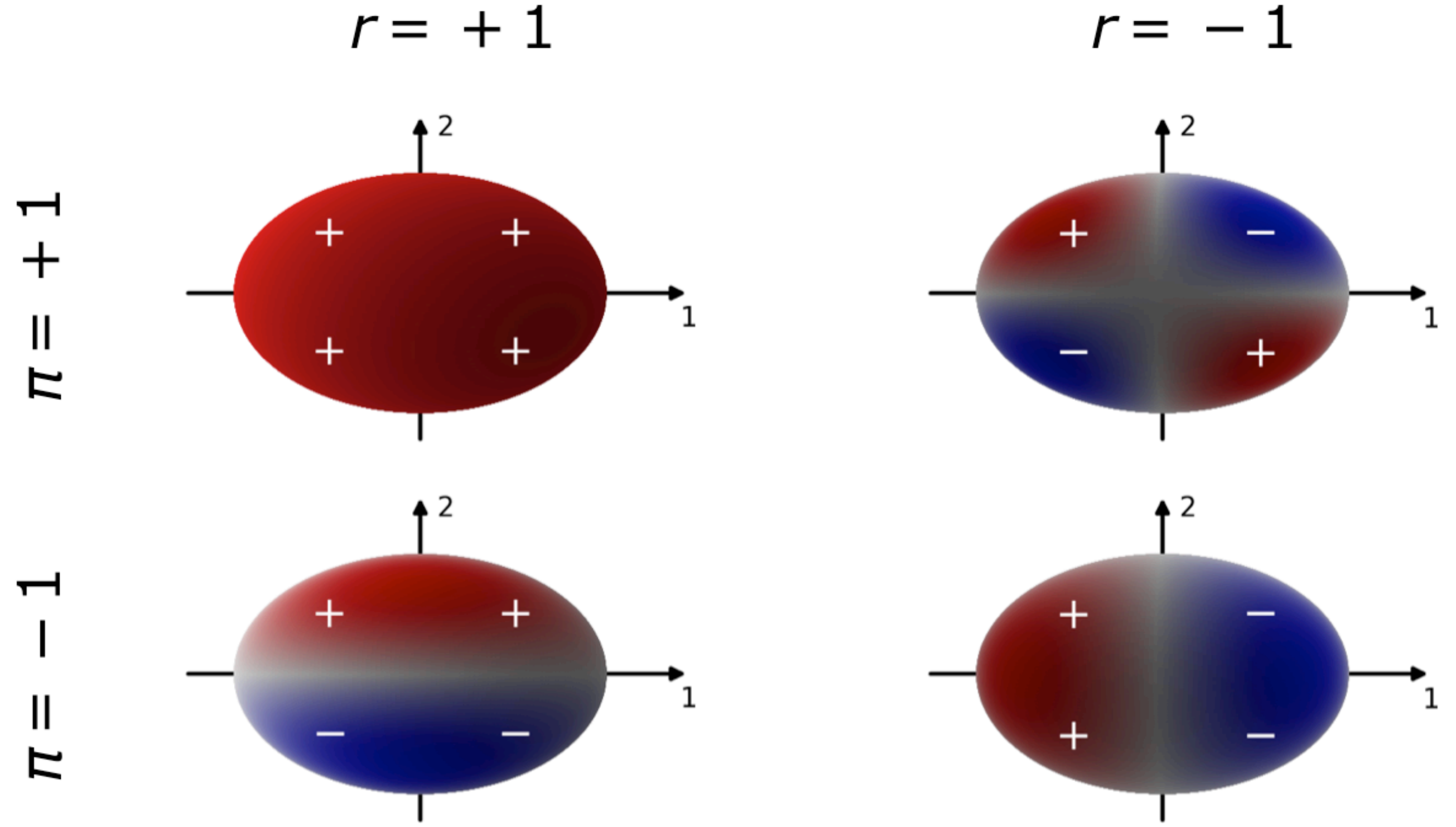


For a rotational band with $K^\pi = 0^+$ one finds $r = (-1)^J$, i.e.

$$J = \begin{cases} 0^+, 2^+, 4^+, \ldots & \text{for} \quad r = +1 \\ 1^+, 3^+, 5^+, \ldots & \text{for} \quad r = -1 \end{cases}$$

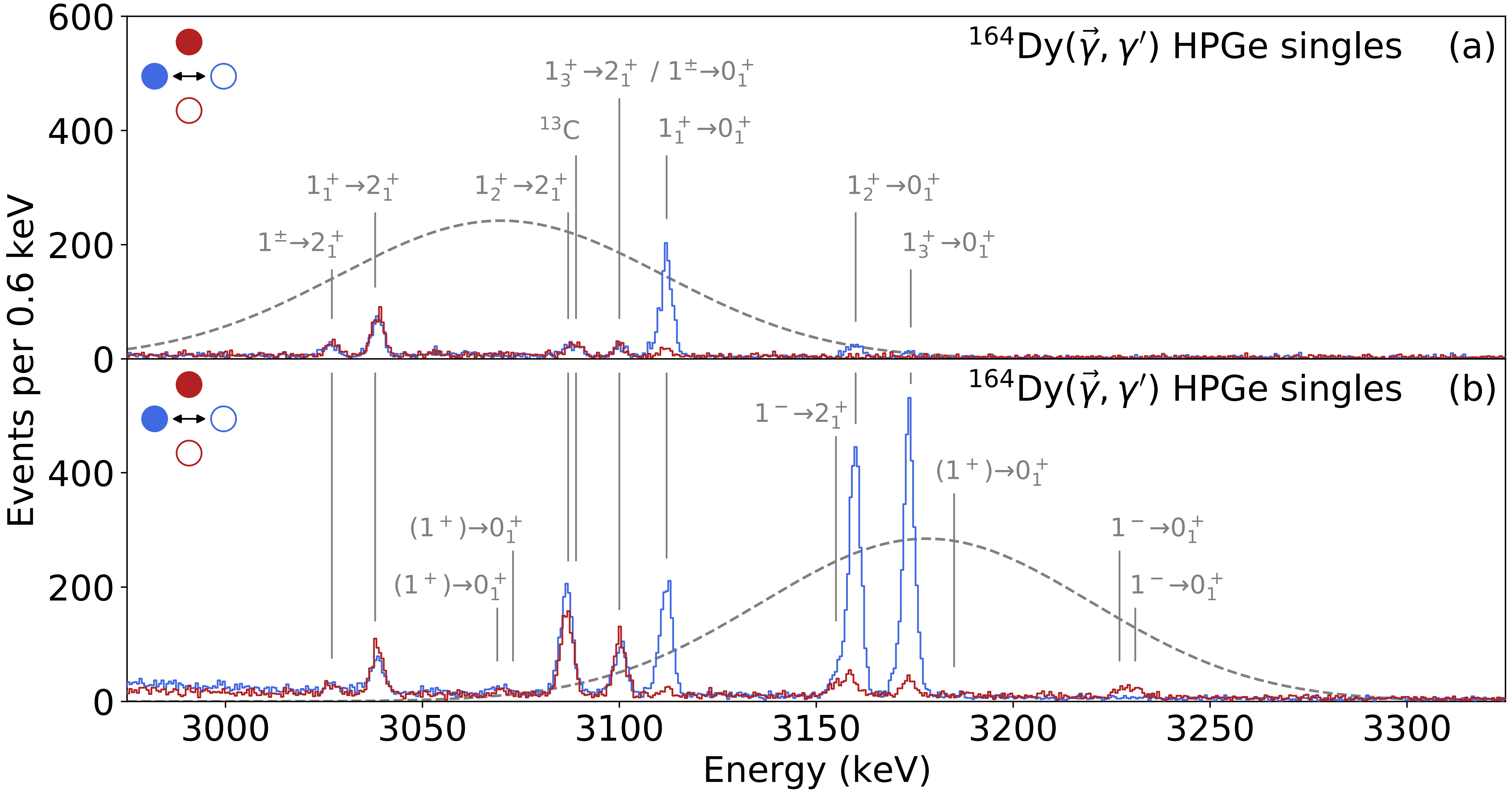
For bands with $K > 0$ the standard selection rule

$$J = K, K+1, K+2, \ldots$$

is obtained.

Branching ratios of 1^+ states of ^{164}Dy

Branching ratios can commonly be compared with Alaga predictions. For axially-symmetric deformed nuclei and if bandmixing is small, the agreement is exceptionally good.



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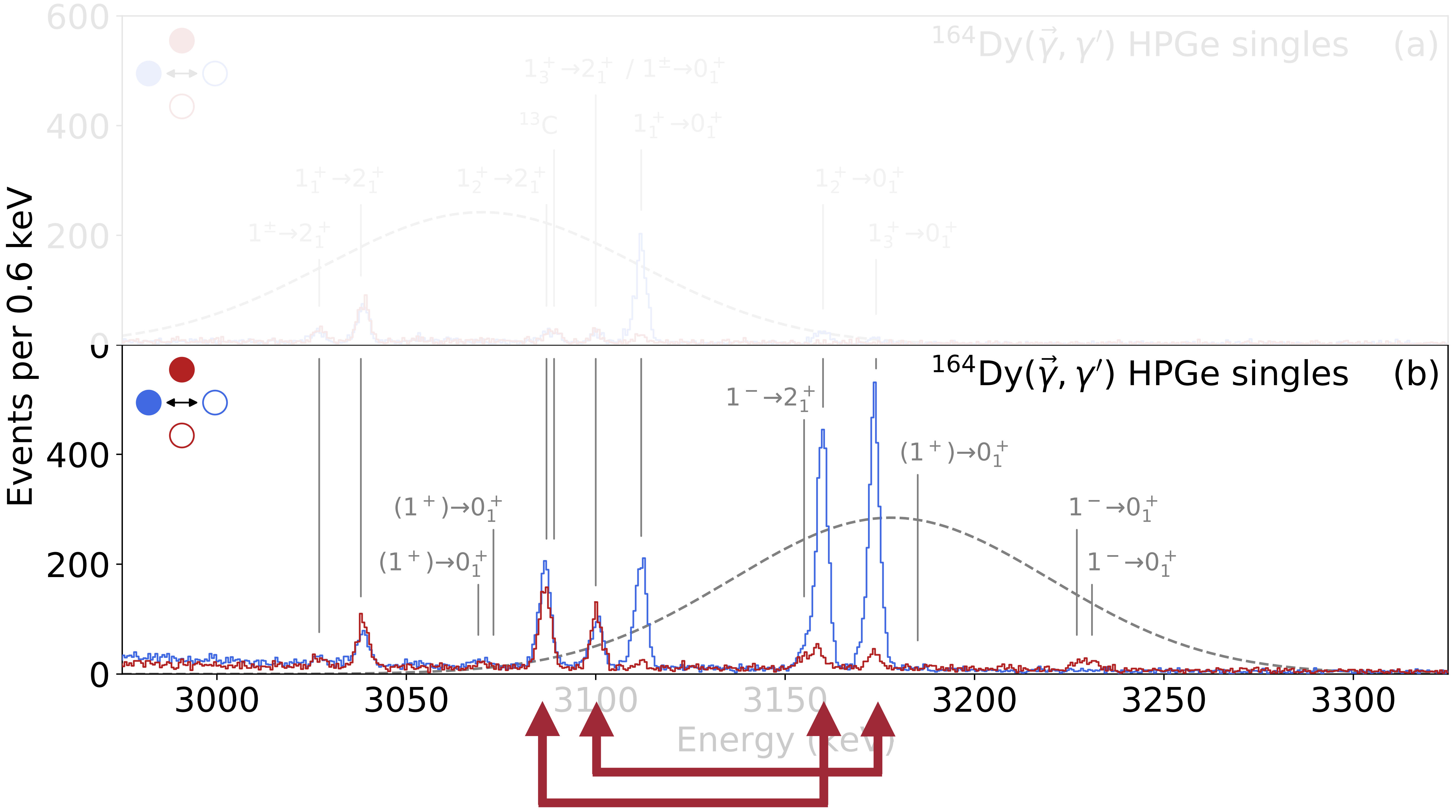

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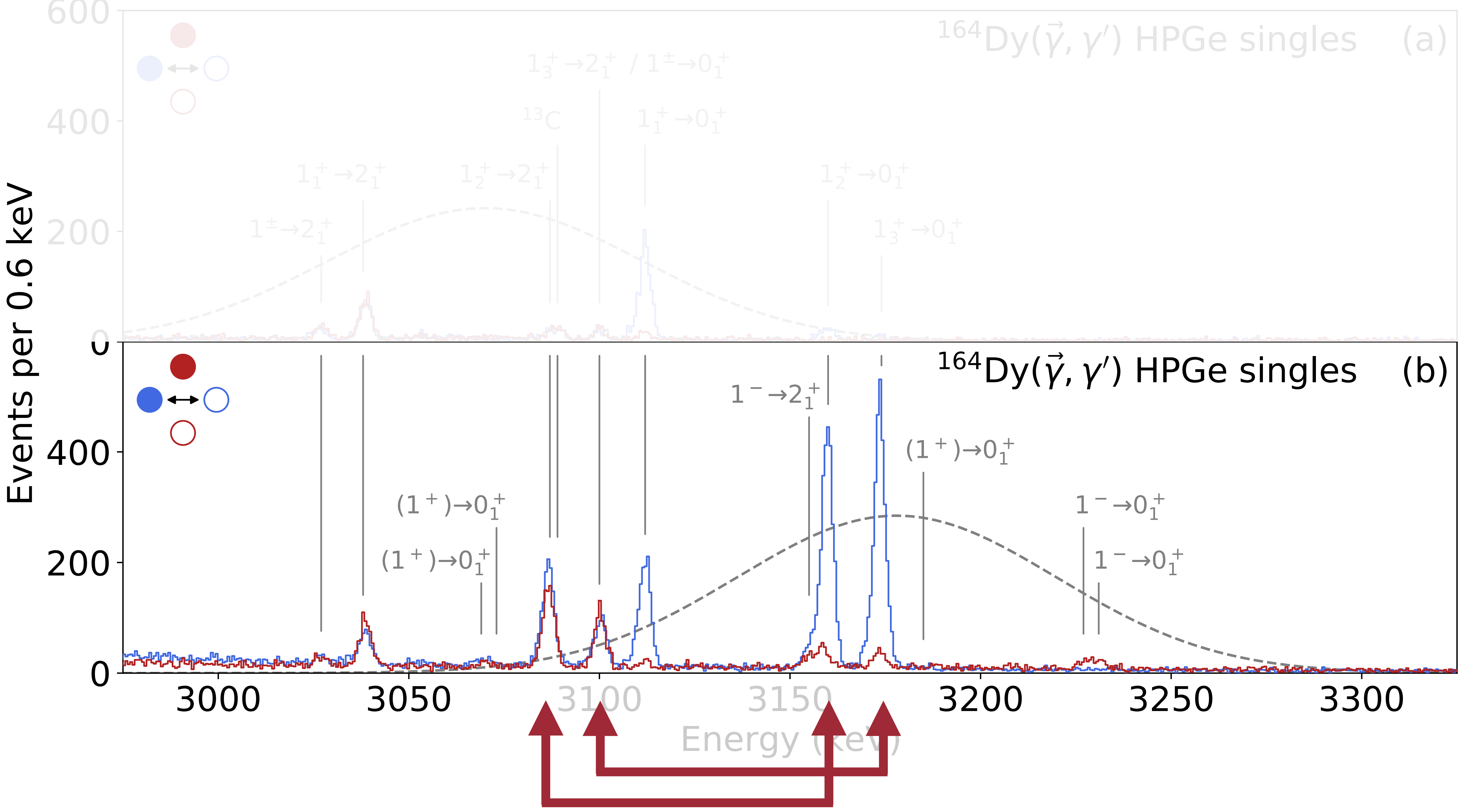

Values for $M1$ branching ratios:

3111 keV: $R_{1\rightarrow 2/0} = 49.5^{+5.2}_{-4.7}$

3159 keV: $R_{1\rightarrow 2/0} = 61.2^{+5.5}_{-5.8}$

3173 keV: $R_{1\rightarrow 2/0} = 26.9^{+2.9}_{-2.6}$

Alaga: $R_{1\rightarrow 2/0} = 50$

Two-state model for K mixing

The wave functions of dipole states can only comprise components with projection quantum numbers $K = 0$ and $K = 1$.

Choose

$$\begin{pmatrix} |1_A\rangle \\ |1_B\rangle \end{pmatrix} = \begin{pmatrix} \alpha & \beta \\ -\beta & \alpha \end{pmatrix} \begin{pmatrix} |1_{K=0}\rangle \\ |1_{K=1}\rangle \end{pmatrix}$$

with $\gamma = \beta/\alpha$ and

$$Z = \frac{\langle K_f = 1 ||| T(M1) ||| K_i = 0\rangle}{\langle K_f = 0 ||| T(M1) ||| K_i = 0\rangle}.$$

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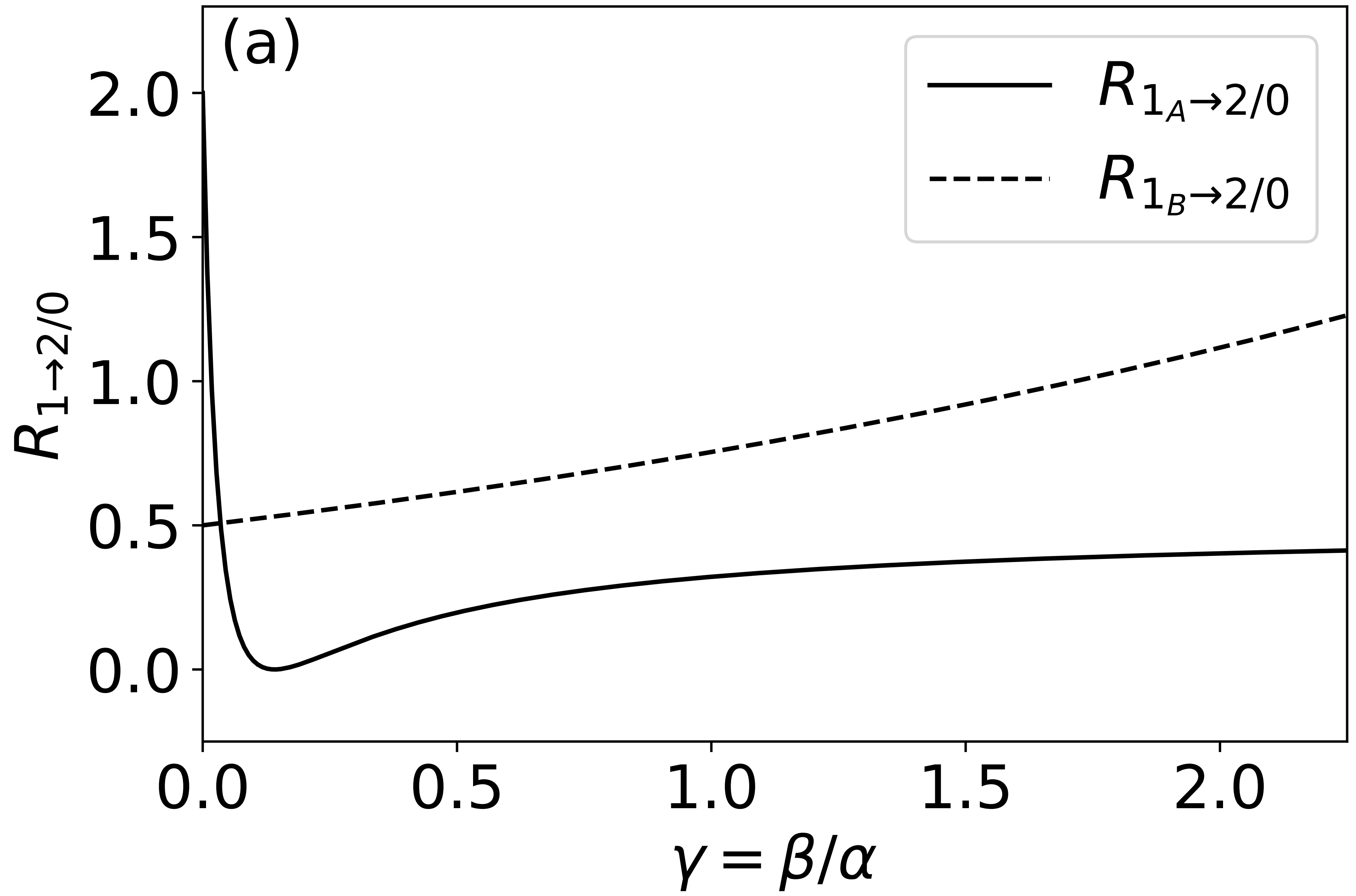


This yields

$$R_{1_A \to 2/0} = \left[\frac{\gamma Z + \sqrt{2}}{1 + \sqrt{2}\gamma Z}\right]^2 \quad \text{and} \quad R_{1_B \to 2/0} = \left[\frac{\sqrt{2}\gamma + Z}{\sqrt{2}Z - \gamma}\right]^2.$$

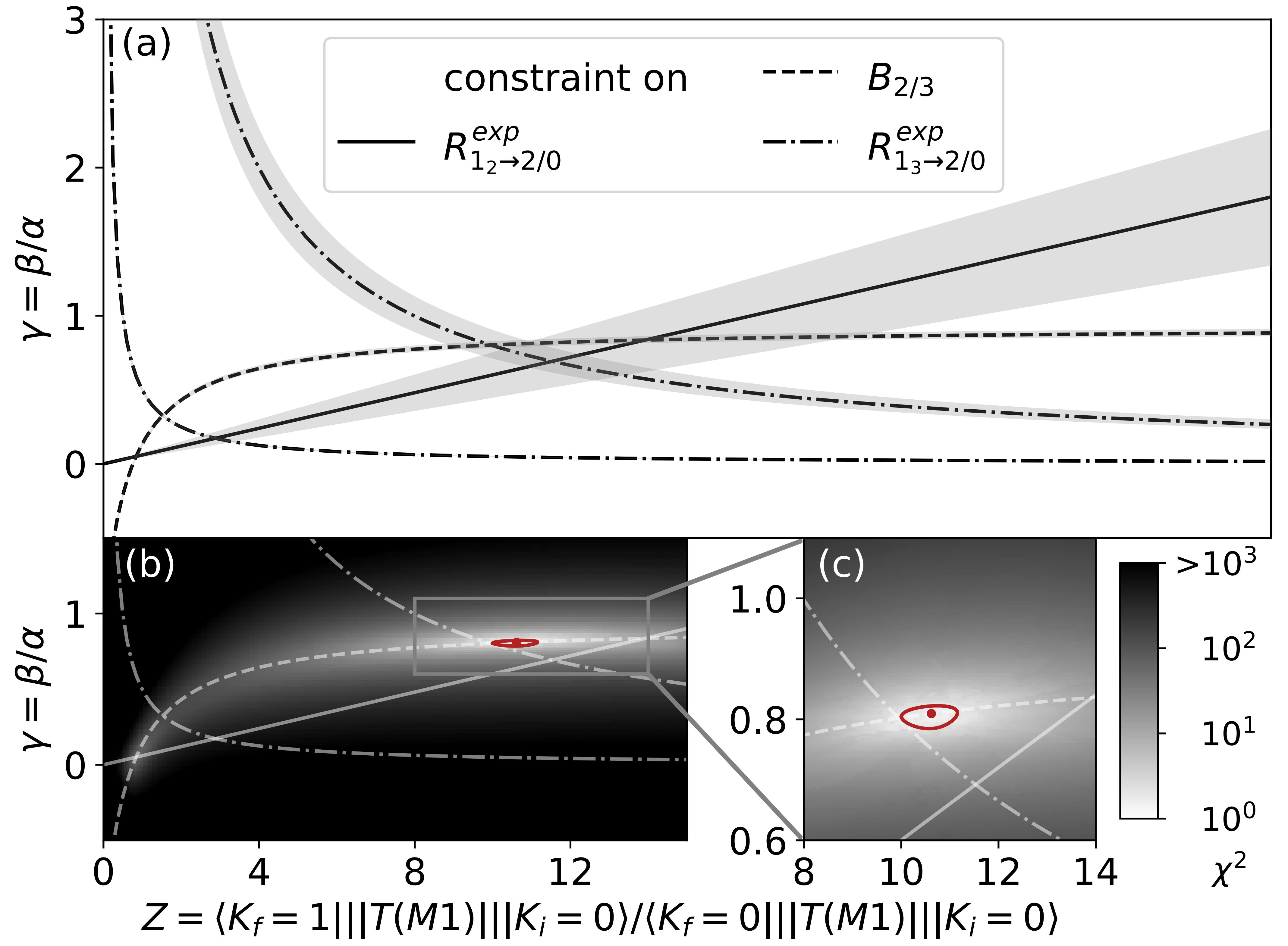
Mixing matrix element and $\Delta K = 0$ $M1$ strength

From the branching ratios and excitation strengths of the involved 1^+ states the amount of mixing is deduced.

Resulting mixing parameters:

$$\alpha^2 = 0.60^{+0.02}_{-0.01} \qquad \beta^2 = 0.40^{+0.01}_{-0.02}$$

$$Z = \frac{\langle K_f = 1|||T(M1)|||K_i = 0\rangle}{\langle K_f = 0|||T(M1)|||K_i = 0\rangle} = 10.6^{+1.0}_{-0.7}$$



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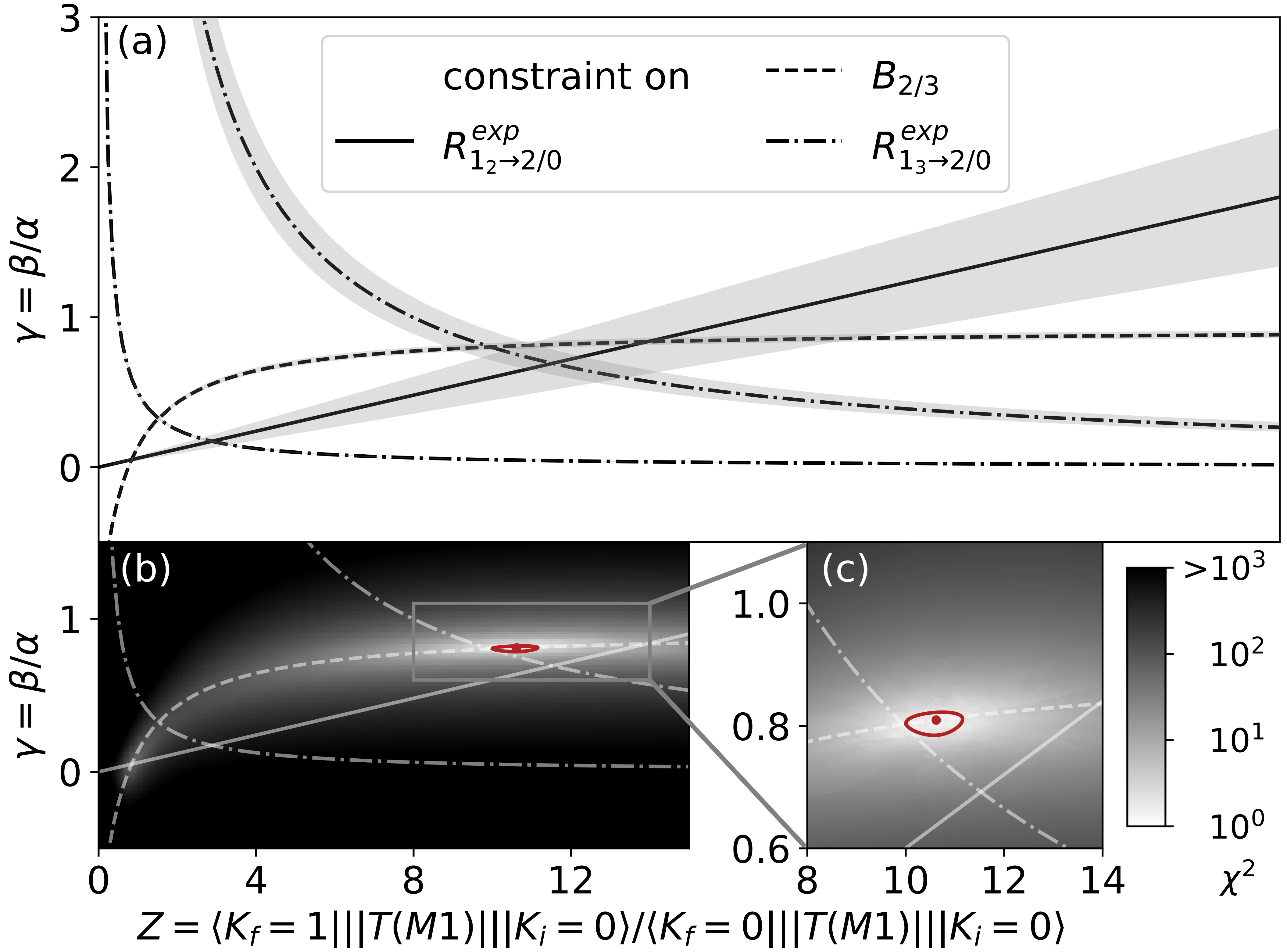
This yields a mixing matrix element of

$$V_{\text{mix}} = 6.85(4)\,\text{keV}$$

and a $\Delta K = 0$ $M1$ excitation strength of

$$B(M1; 0^+_1 \to 1^+_{K=0}) = 0.008(1)\,\mu_N^2.$$



Potential signatures for $1^+_{K=0}$ states

The minuscule excitation strength from the ground state makes the experimental investigation of these states challenging (even at ELI-NP).

Criterion 1: search for comparable mixing scenarios by looking at branching ratios oppositely deviating from Alaga.

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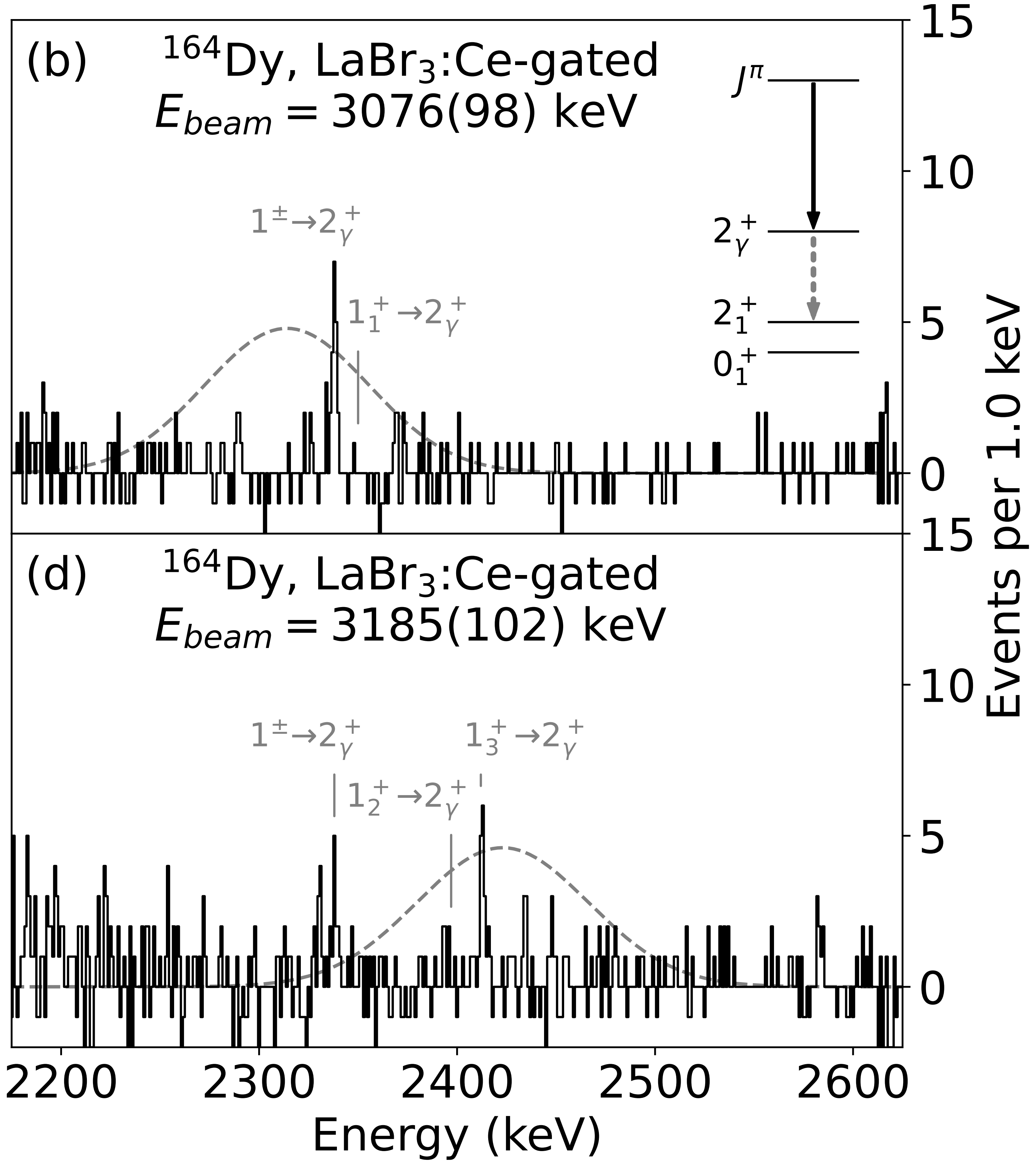

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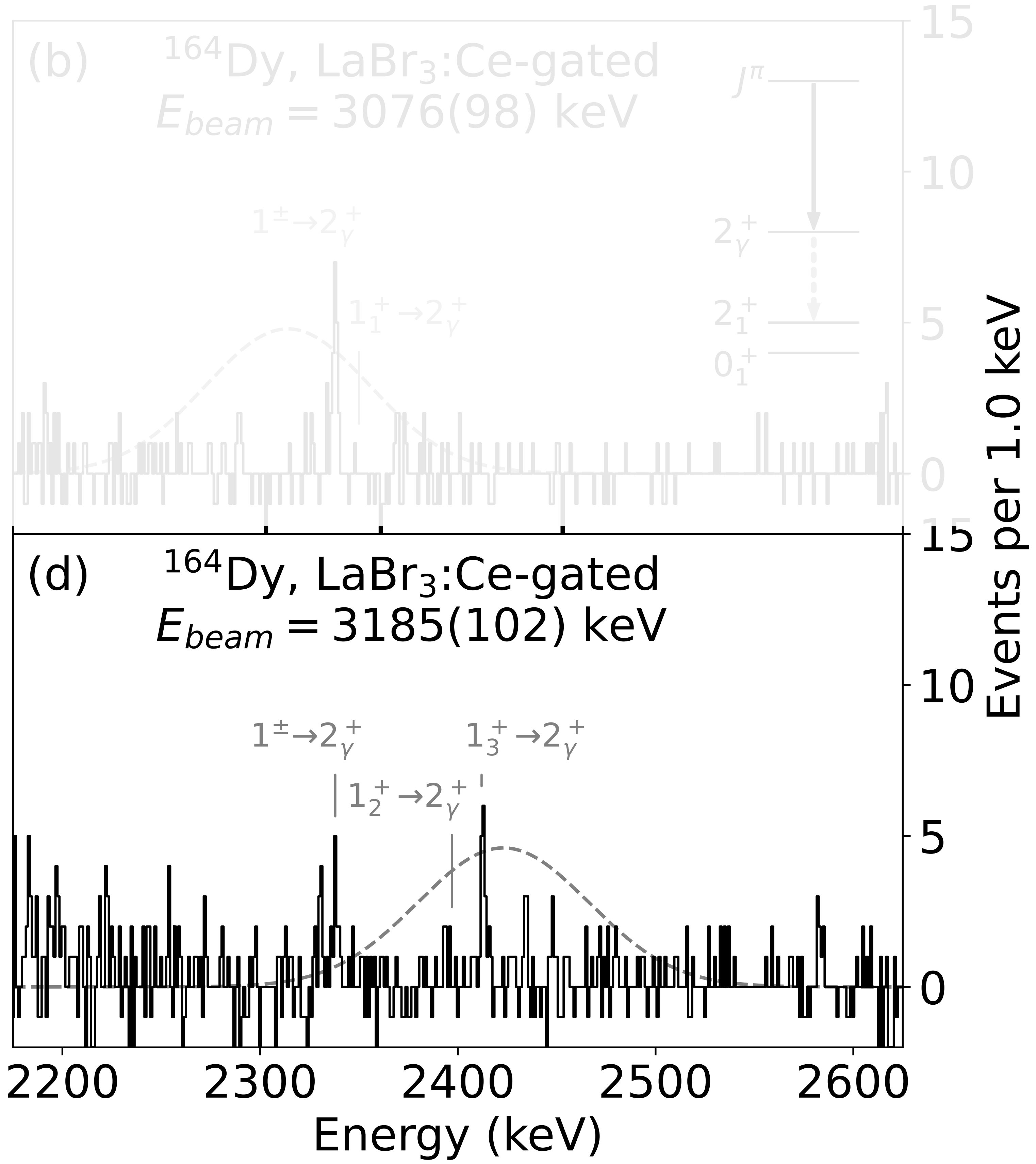

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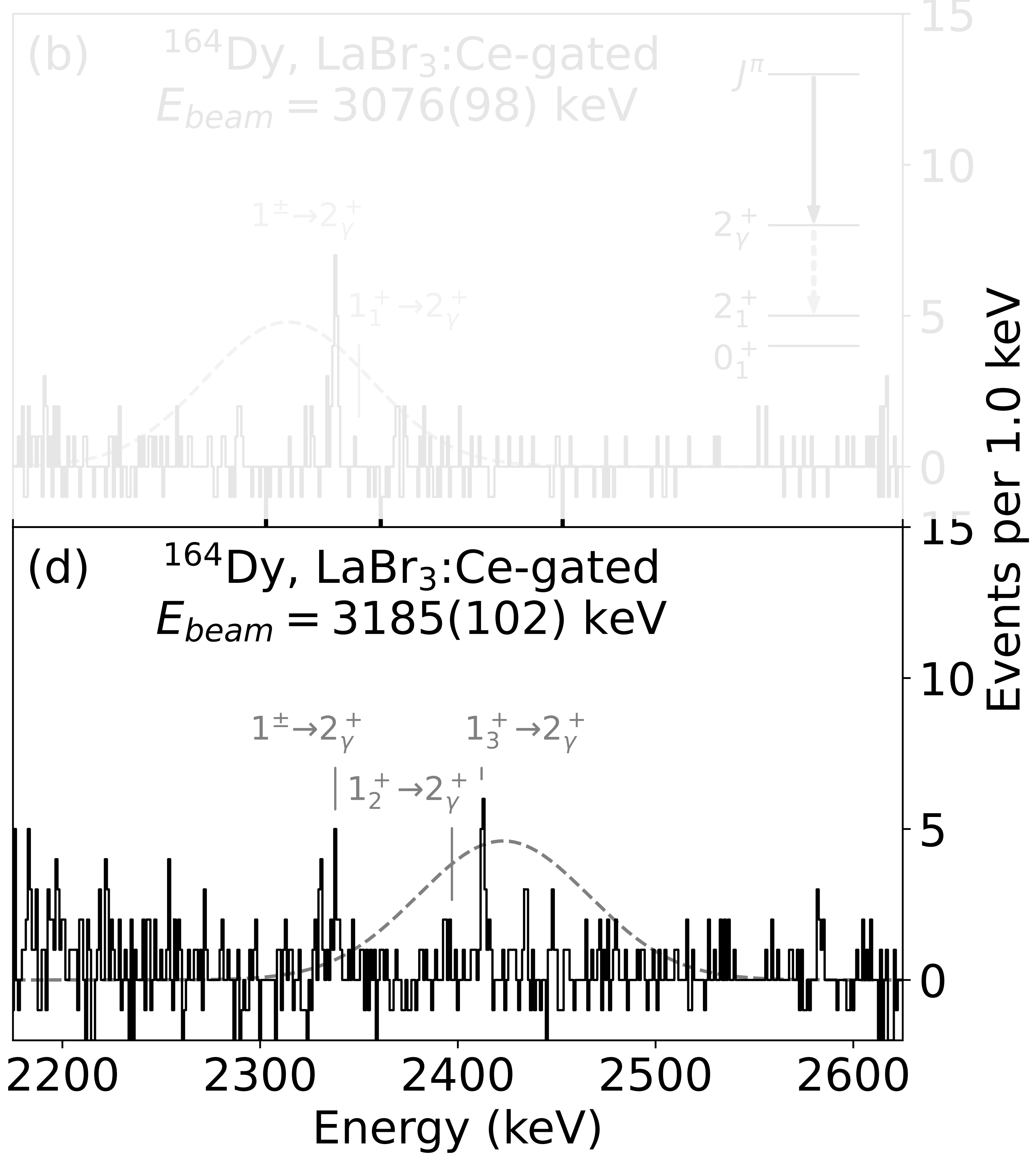
Criterion 2: identify strong transitions to the 2^+_γ state as a potential decay signature of $1^+_{K=0}$ states.



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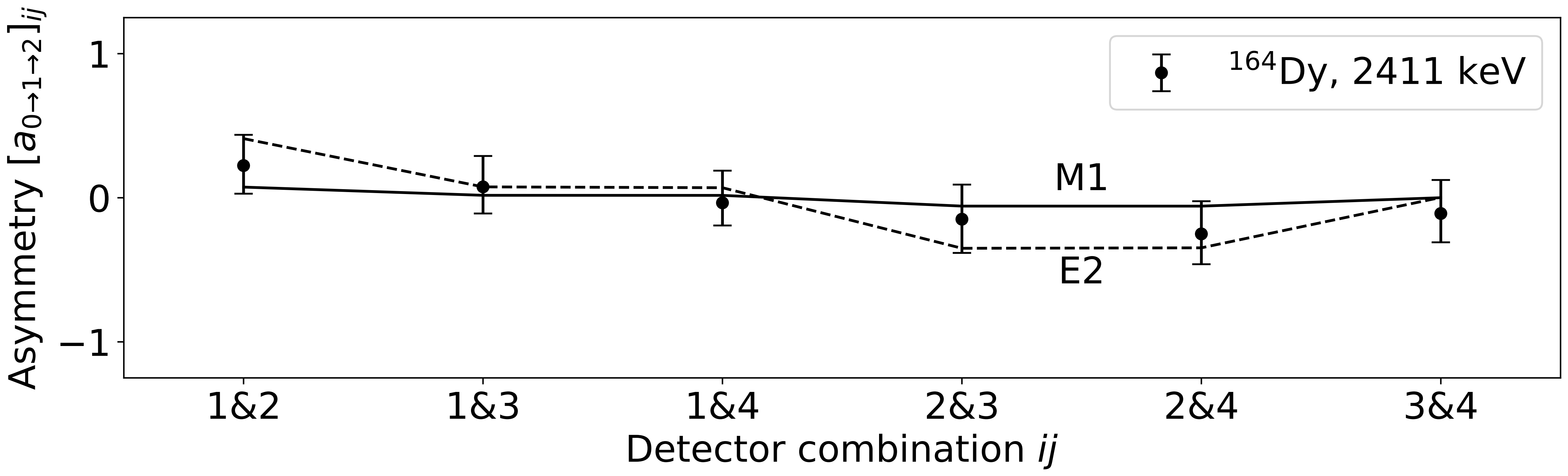

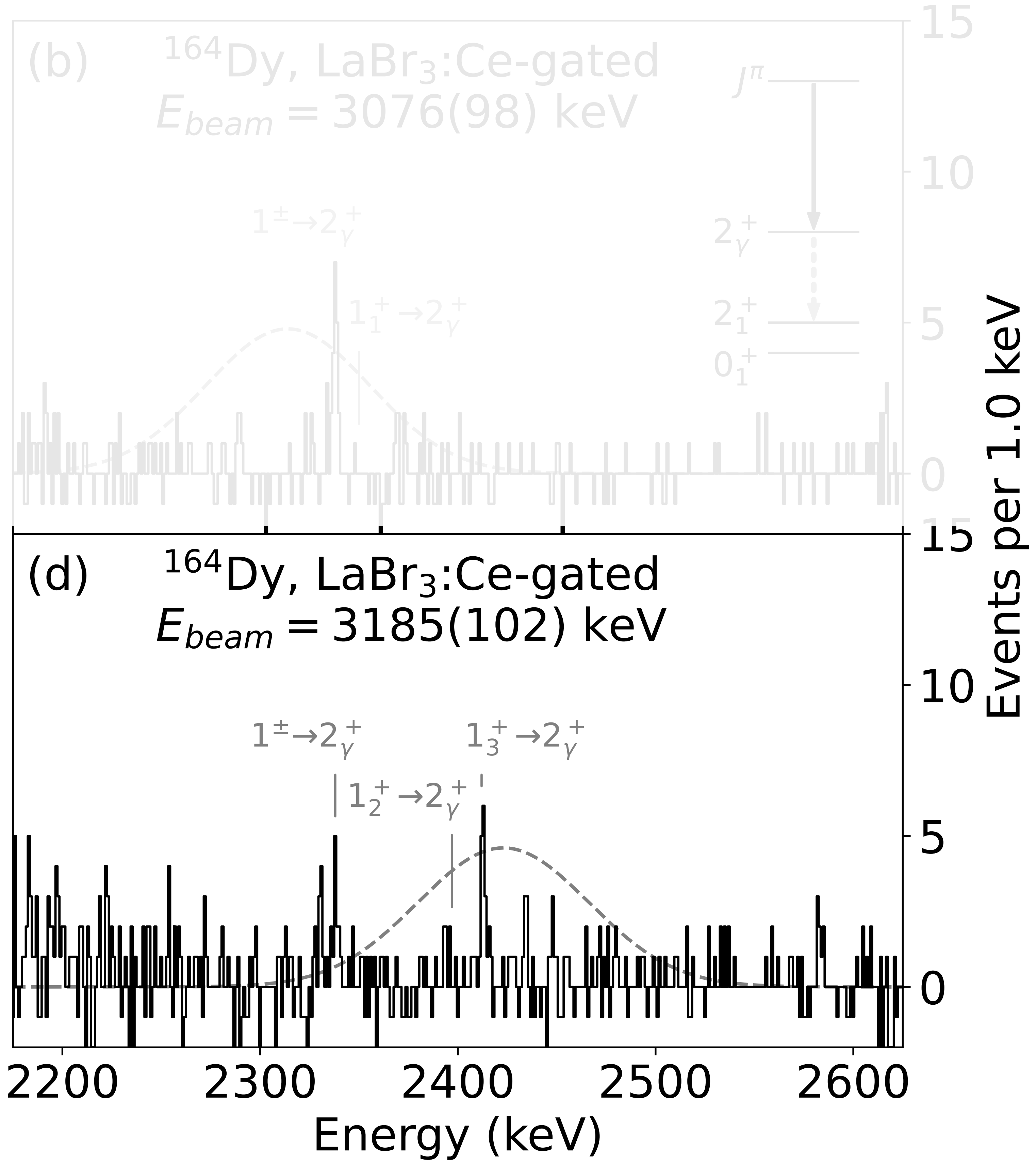

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