E2 ratios and transition radii differences for one-phonon states of spherical nuclei from electron scattering at low momentum transfer

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- Motivation
- Experiment ^{92}Zr
- Analysis and results
- Summary and outlook

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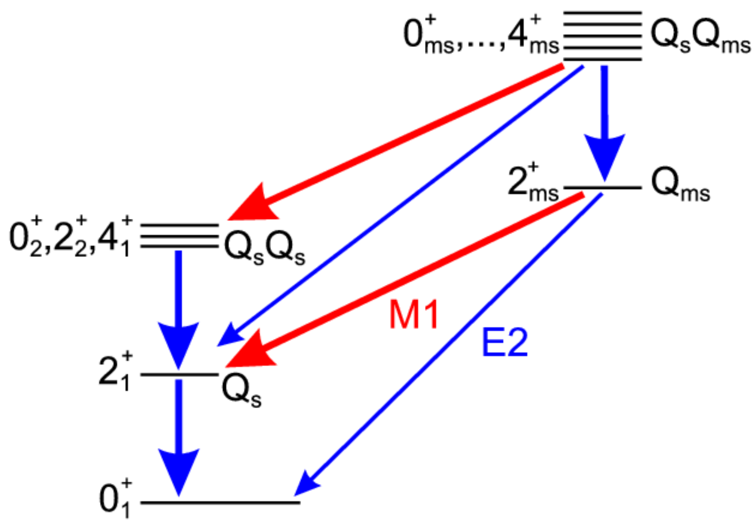
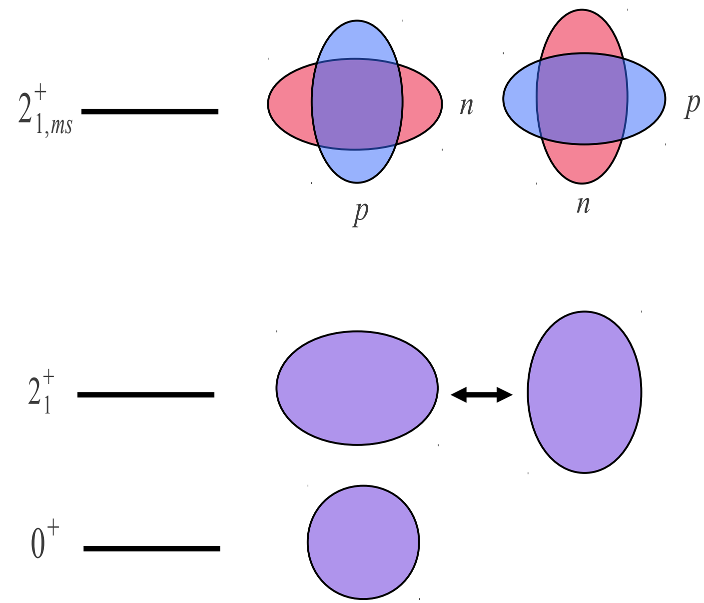
LOEWE – Landes-Offensive zur Entwicklung Wissenschaftlich-ökonomischer Exzellenz

Mixed-symmetry states in vibrational nuclei

Fully symmetric states (FSS)
$F = F_{max}$

Mixed-symmetry states (MSS)
$F = F_{max} - 1$





- Strong E2 transitions for decay of Q_s-phonon
- Weakly collective E2 transitions for decay of Q_{ms}-phonon
- Strong M1 transitions for decay of MSS to FSS

Fully confirmed for ^{94}Mo

N. Pietralla, C. Fransen et al.

^{92}Zr

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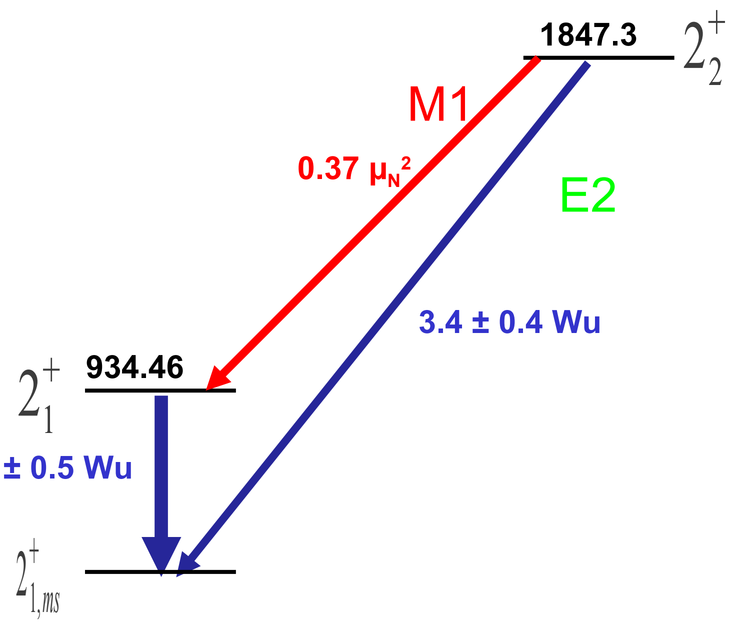
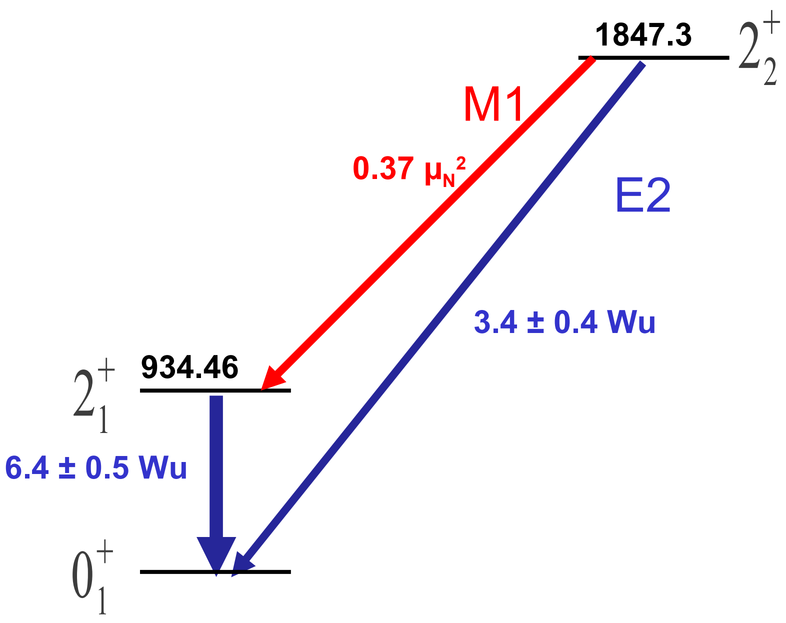
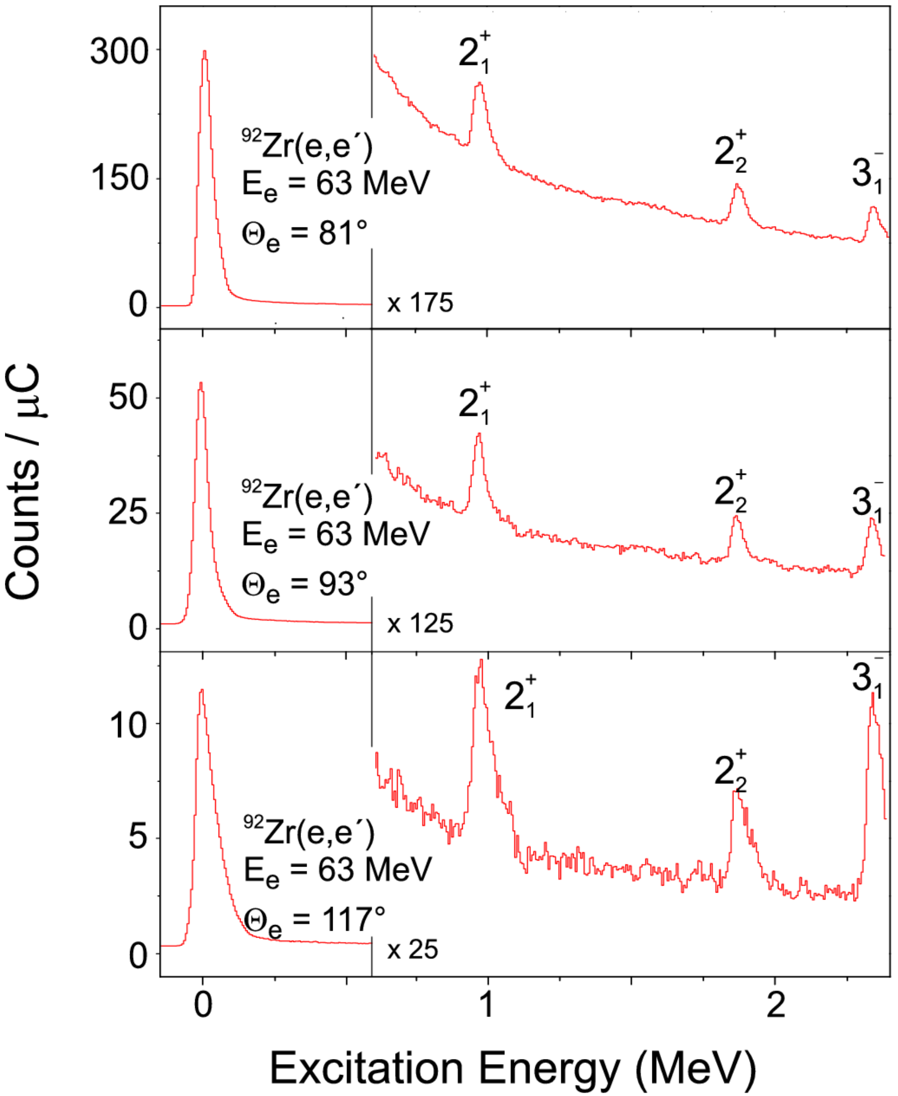


Experiment $^{92}Zr(e,e')$





Model- dependent DWPA Analysis

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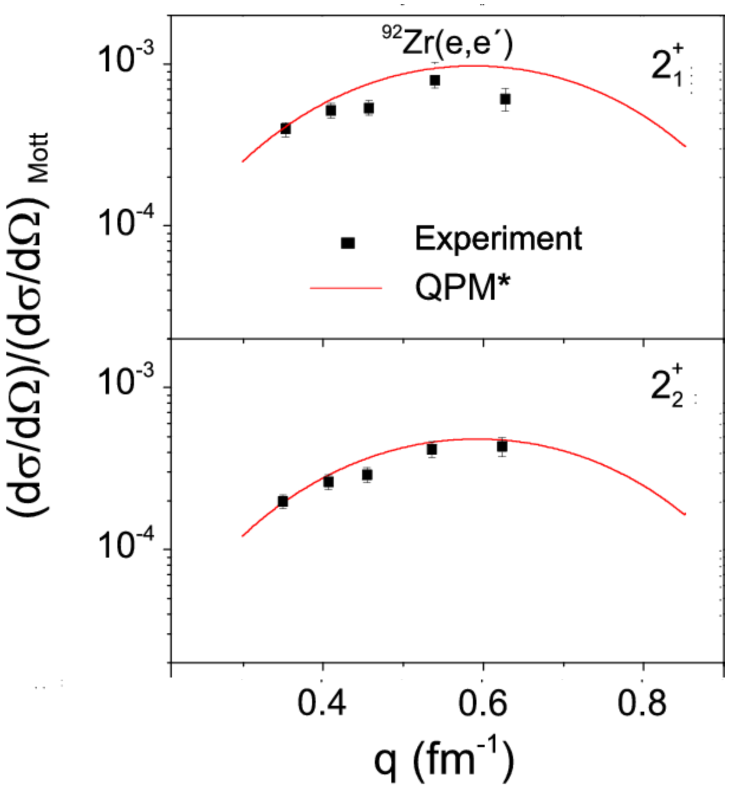


***Form factors from QPM**

$$2_1^+ = 0.77\,\nu\left|2d_{5/2^2}\right\rangle + 0.37\,\pi\left|1g_{9/2^2}\right\rangle + \ldots$$

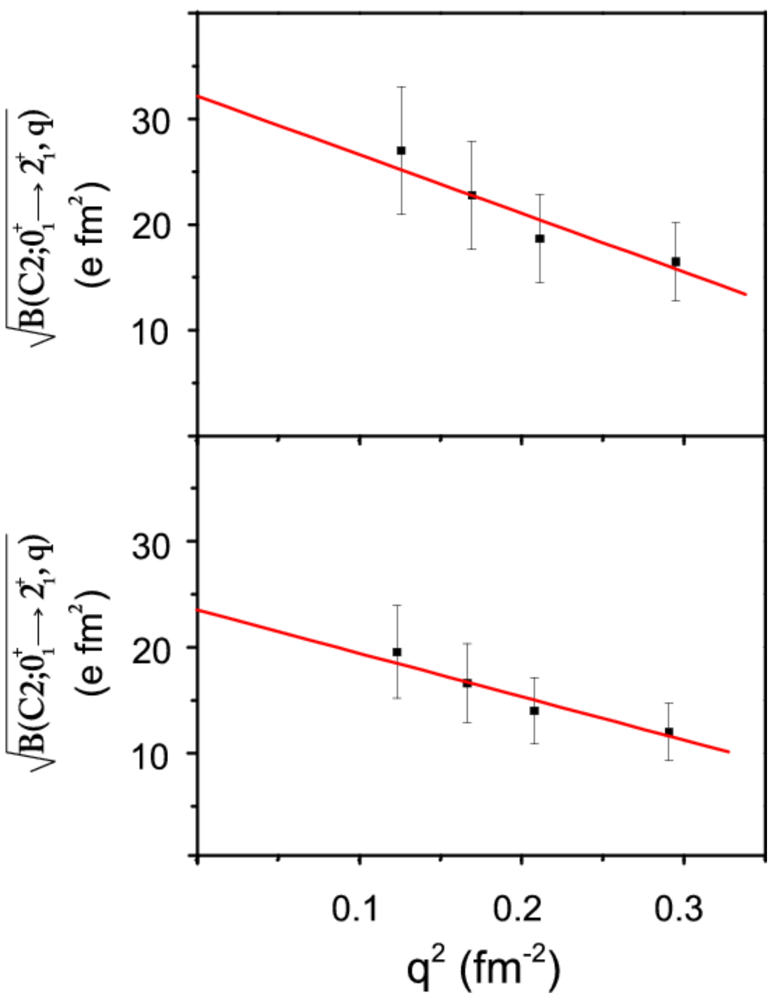
$$2^+_{1,ms}$$

*V. Ponomarev, priv. comm.

	This work: ^{92}Zr(e,e′) Eλ strength in W.u. Form factor scaled to QPM	^{92}Zr(n,n′γ) [1]
$B(E2;2_1^+ \to 0_1^+)$	6.2±0.3	6.4±0.5
$B(E2;2_2^+ \to 0_1^+)$	3.3±0.2	3.4±0.4

[1] Fransen C *et al.* 2005 *Phys. Rev* C **71** 054304

Model-independent extraction of E2 excitation strength

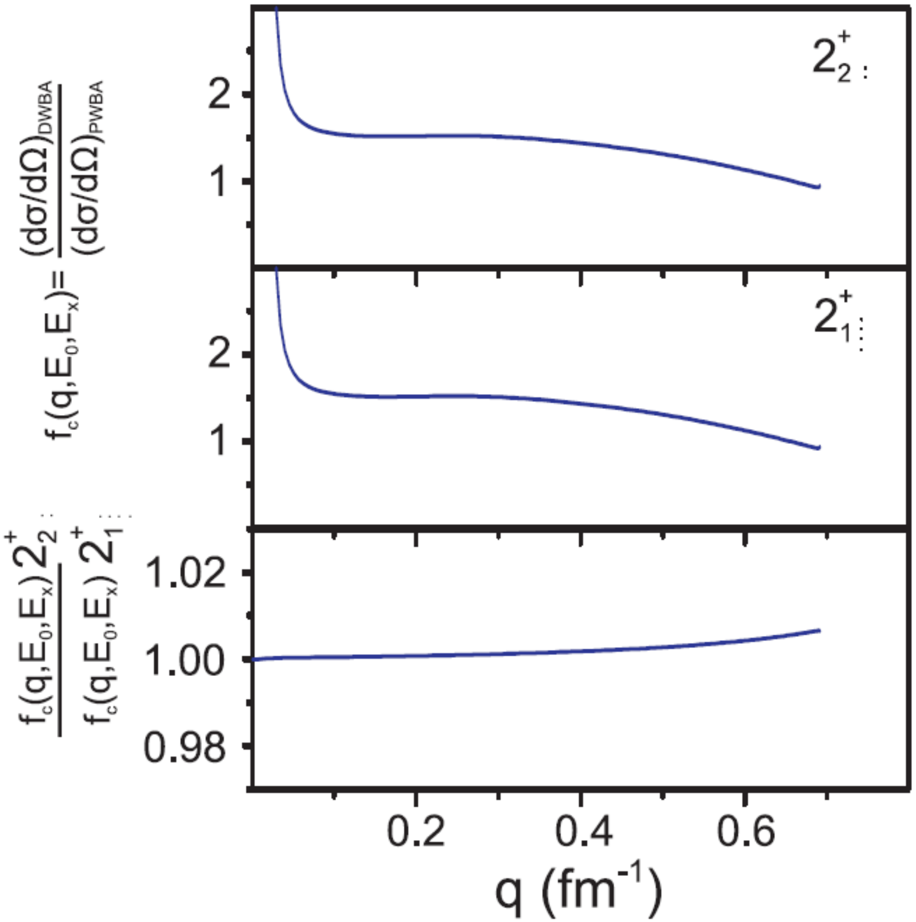


$$\sqrt{B(C\lambda,q)} = \sqrt{B(E\lambda,k)}\left(1 - q^2\frac{R_{tr}^2}{14} + q^4\frac{R_{tr}^4}{504}\cdots\right)$$

$$\sqrt{B(E\lambda,q)}\uparrow = \frac{k_0^2 R}{\alpha^2 a_\lambda q^{2\lambda}}\left[V_L(\theta)\left(\frac{\lambda}{\lambda+1} + \frac{K^2}{q^2}\frac{V_T(\theta)}{V_L(\theta)}\right)\right]^{-1}\left(\frac{d\sigma}{d\Omega}\right)_{E\lambda}$$

$$R_{\mathrm{tr}}^2 = \frac{\int \rho_\lambda(r) r^{\lambda+4}\,\mathrm{d}r}{\int \rho_\lambda(r) r^{\lambda+2}\,\mathrm{d}r}$$

Coulomb correction factors



The ratio of momentum-transfer dependent Coulomb correction factors is very close to 1 In region of intereset.

Model-independent relative extraction of E2 excitation strength

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$$\frac{\sqrt{B(C\lambda,q_2)_{2_2^+}}}{\sqrt{B(C\lambda,q_1)_{2_1^+}}} = \frac{\sqrt{B(E2,k)_{2_2^+}}}{\sqrt{B(E2,k)_{2_1^+}}} \frac{\left(1 - q_2^2\frac{R_2^2}{14} + q_2^4\frac{R_2^4}{504}\cdots\right)}{\left(1 - q_1^2\frac{R_1^2}{14} + q_1^4\frac{R_1^4}{504}\cdots\right)}$$

$$q_2^2 = q_1^2 + \delta q^2$$

$$R_1^2 = R_2^2 + \Delta R^2$$

$$R_1 = 4.762,\ \text{fm}\ \delta q^2 = -0.0021\ \text{fm}^{-2}$$

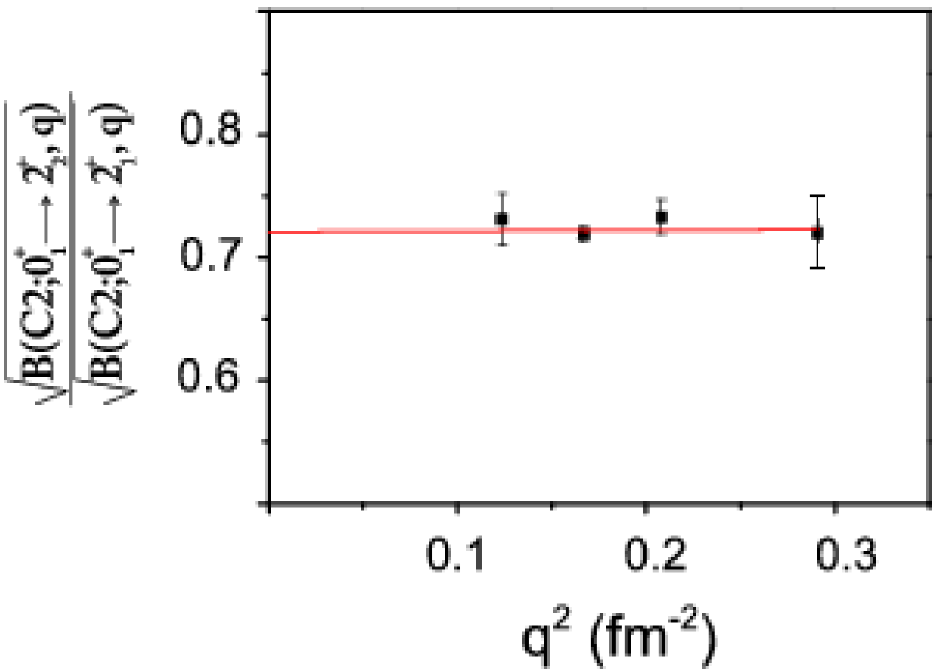
$$\frac{\sqrt{B(C\lambda,q_2)_{2_1^+}}}{\sqrt{B(C\lambda,q_1)_{2_1^+}}} = \frac{\sqrt{B(E2,k)_{2_2^+}}}{\sqrt{B(E2,k)_{2_1^+}}} (1.00341 + 0.0712929 q_1^2 \Delta R^2 + 0.02608 q_1^4 \Delta R^2)$$

$$\frac{\left(\frac{d\sigma}{d\Omega}\right)_{E\lambda,2_2^+}}{\left(\frac{d\sigma}{d\Omega}\right)_{E\lambda,2_1^+}} \sim \frac{A^{exp}_{in,2_2^+}}{A^{exp}_{in,2_1^+}}$$

Results

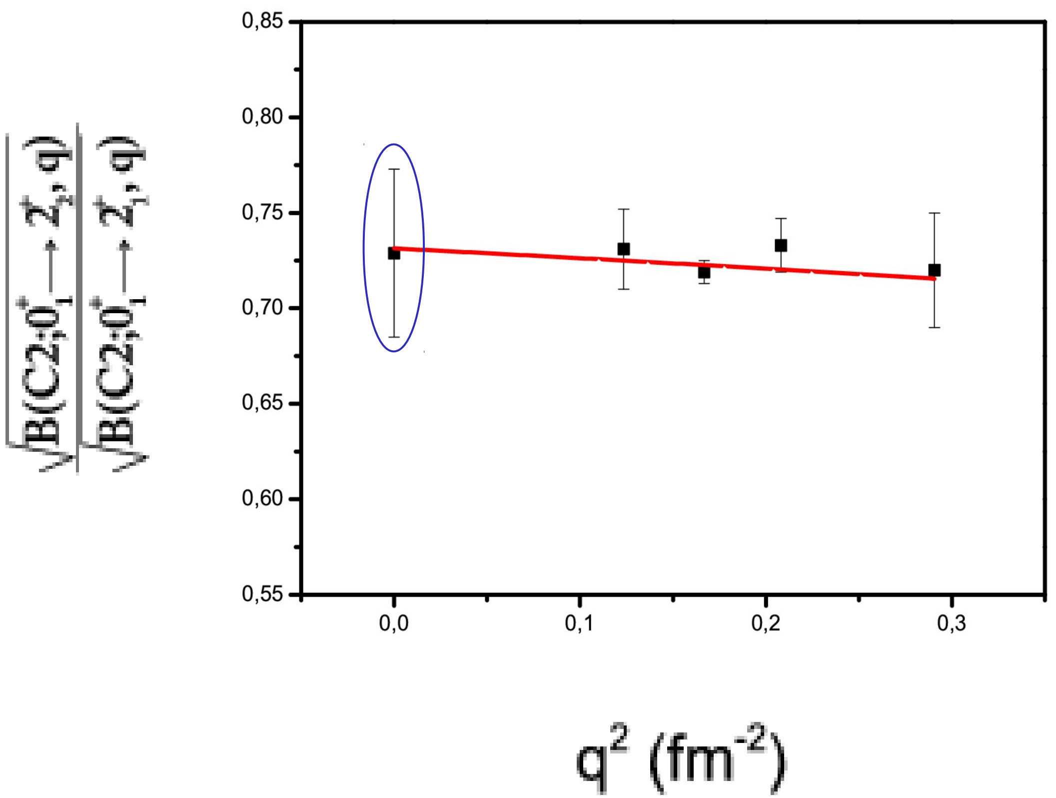
$$\frac{\sqrt{B(E2,k)_{2_2^+}}}{\sqrt{B(E2,k)_{2_1^+}}} = 0.712 \pm 0.021 \Rightarrow \frac{B(E2,k)_{2_2^+}}{B(E2,k)_{2_1^+}} = 0.507 \pm 0.029$$

$$B(E2,k)_{2_1^+} = 6.4 \pm 0.5 \text{ W.u.} \Rightarrow \mathrm{B(E2,k)}_{2_2^+} = 3.25 \pm 0.29 \text{ W.u.} \quad 3.4 \pm 0.4 \text{ W.u.}$$



$$\Delta R^2 = 0.741 \pm 2.295 \text{ fm}^2$$

More data



$$R_1^2 - R_2^2 = \Delta R^2$$

$$\Delta R^2 = -0.94 \pm 0.31 \text{ fm}^2$$

$$\Delta R = -0.098 \pm 0.031 \text{ fm}$$

$$\text{QPM: } \Delta R = -0.07 \text{ fm}$$

Summary an outlook

- High-resolution electron scattering experiments performed on ^{92}Zr
- Model-independent: B(E2) B(E3) extracted
- Model-dependent: B(E2) extracted, neu observable: Transtion radius
- Application to other nuclei