Scissors Mode Strength in the Quasicontinuum

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Supported by DFG under contract SFB 1245 and NNRC (Project No. 341985)

The Scissors Mode

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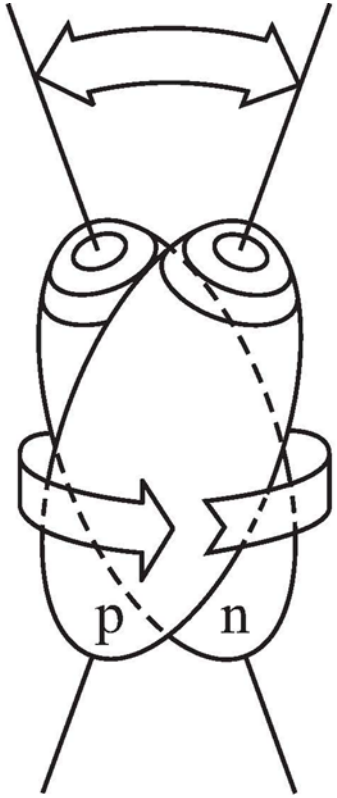
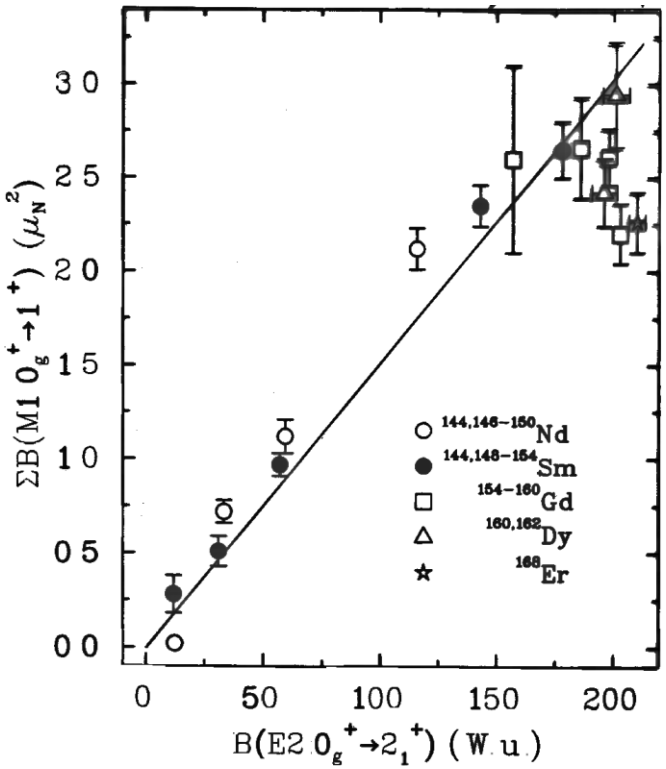
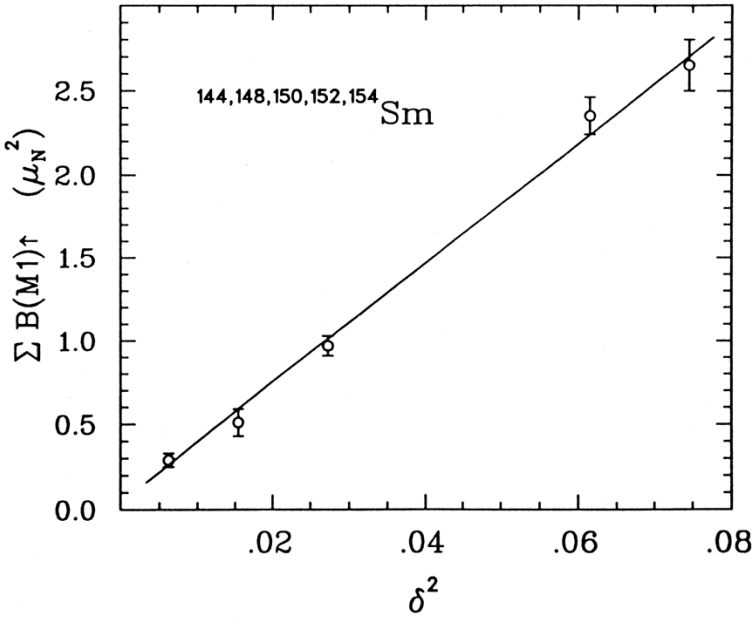
K. Heyde, P. von Neumann-Cosel, A. Richter,
Rev. Mod. Phys. 82, 2375 (2010)







Sum-Rule Approach

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J. Enders et al., Phys. Rev. C 71, 014306 (2005)

- Sum rules $S_j(\mathcal{M}) = \sum_i B_i(\mathcal{M})\, E_{xi}^j$

$$S_{+1}(M1) = \frac{3}{5\pi}\, r_0^2\, A^{5/3}\, \delta^2\, E_{GDR}^2\, m_N\, g_{IV}^2$$

$$S_{-1}(M1) = \frac{3}{16\pi}\, \Theta_{M1}\, g_{IV}^2$$

$$E_x = \sqrt{S_{+1}/S_{-1}}$$

$$B(M1) = \sqrt{S_{+1} \cdot S_{-1}}$$

- Sum rules depend on two parameters:

$$g_{IV} \approx g_{IS} = g(2_1^+)$$

$$\Theta_{IV} = \Theta_{IS} = 3\hbar^2/E_{2_1^+}$$

Parameter-Free Sum Rule Description

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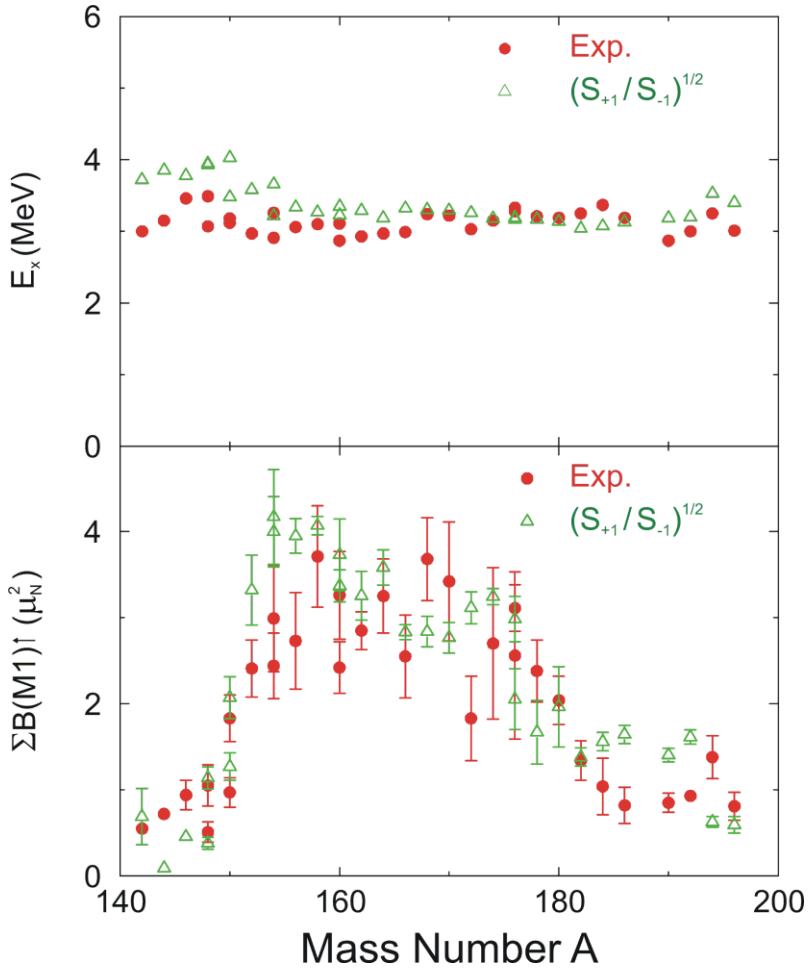
J. Enders et al., Phys. Rev. C 71, 014306 (2005)



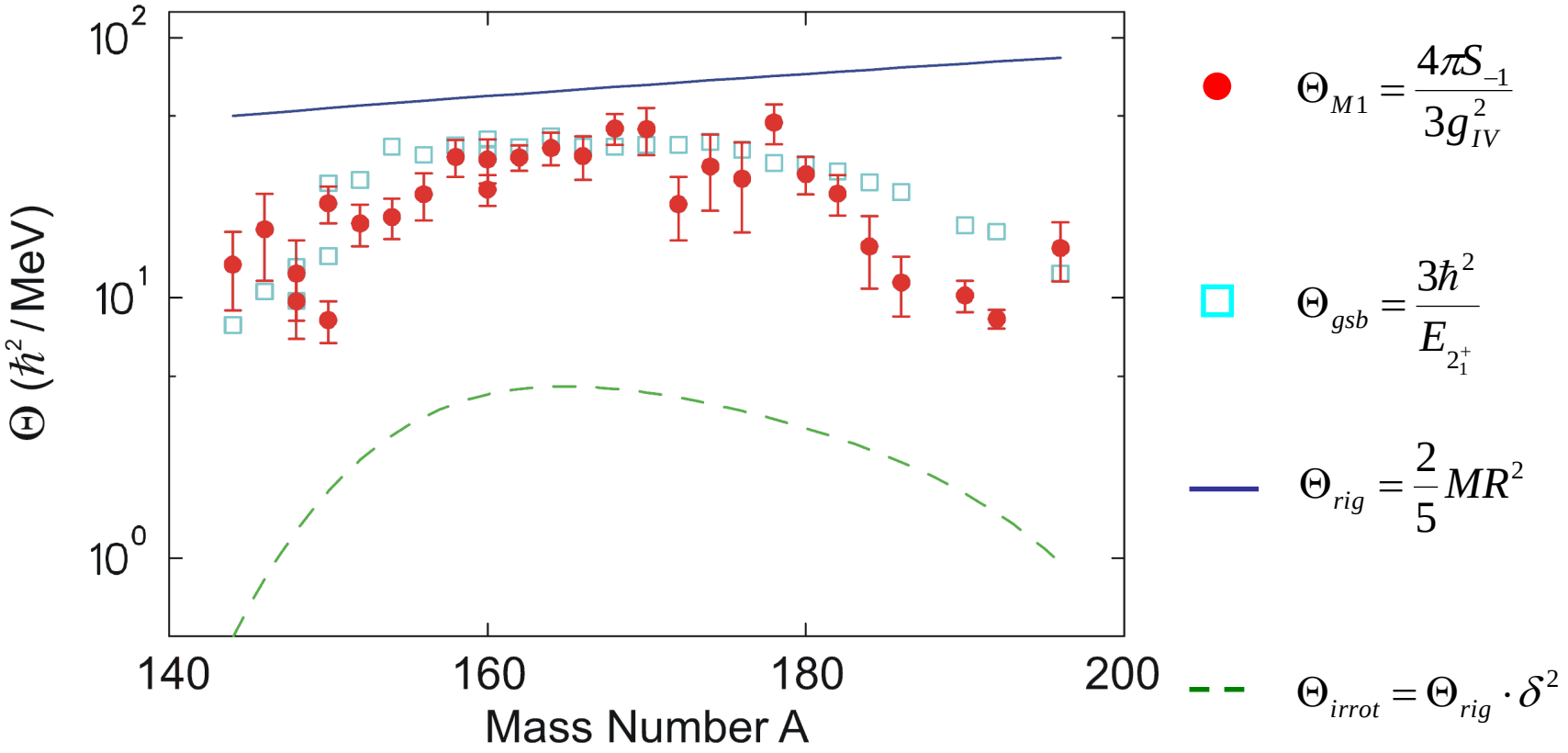
$$E_x \sim \sqrt{E_{2_1^+}} \cdot \delta \approx const.$$

contributions from deformation and moment of inertia cancel each other

$$B(M1) \sim \frac{\delta}{\sqrt{E_{2_1^+}}} \sim \delta^2$$

"δ^2 law" results from an interplay of deformation and the moment of inertia

Moments of Inertia



- Ground-state correlations reduce MoI with respect to rotational limit

Scissors Mode in Quasicontinuum γ Decay

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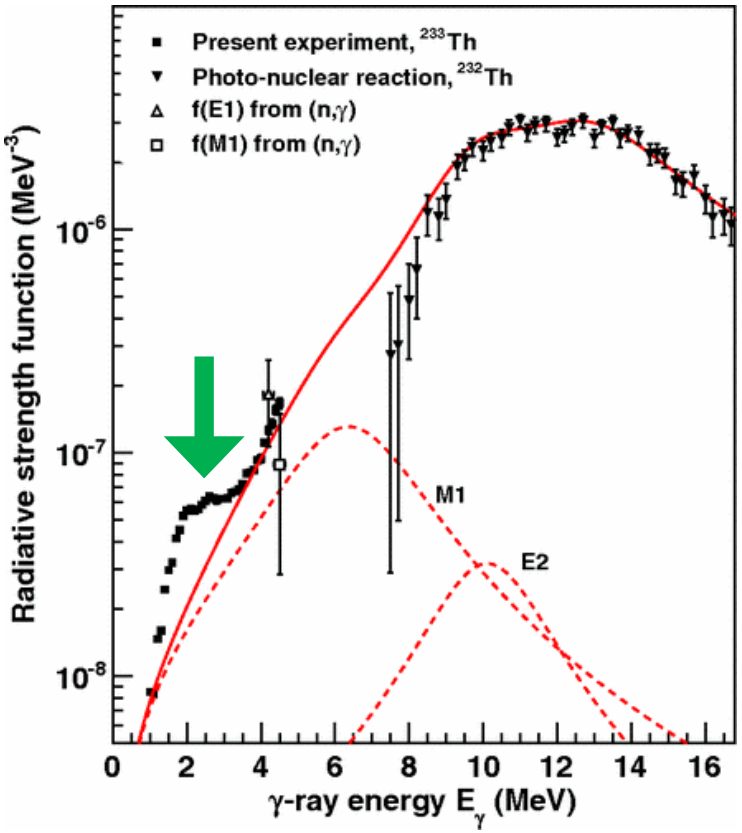
- First observation in γγ cascades after neutron capture
  M. Krticka et al., Phys. Rev. Lett. 92, 172501 (2004)

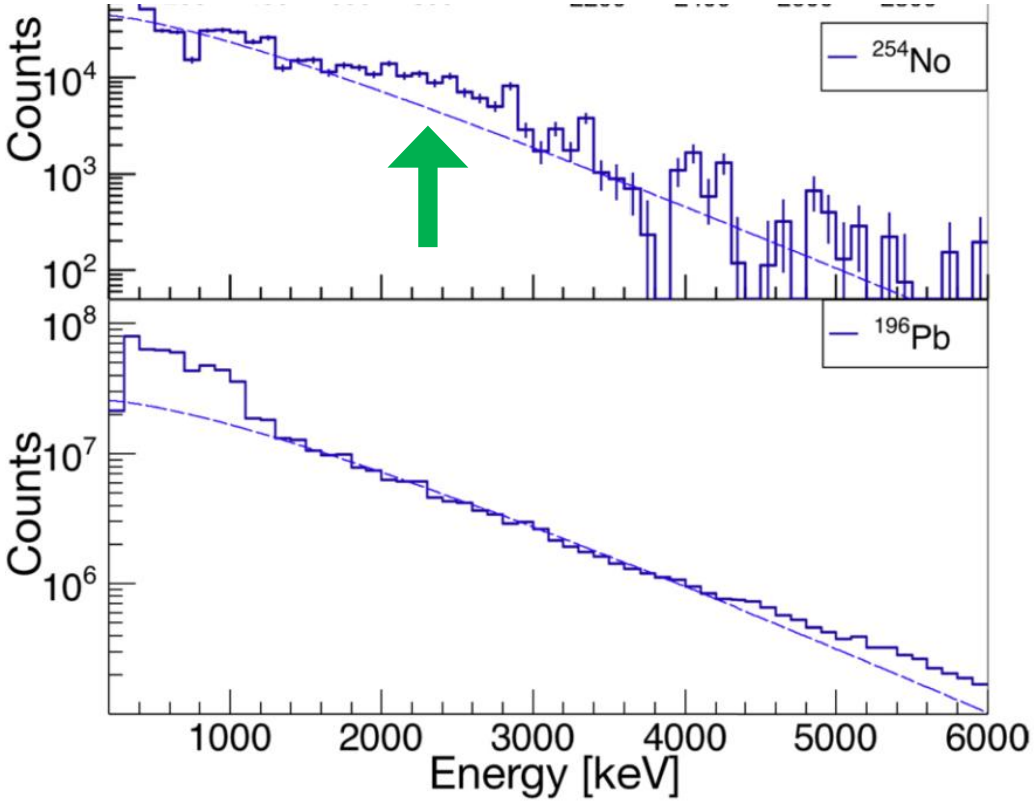
M. Guttormsen et al., Phys. Rev. Lett. 109, 162503 (2012)



- Oslo experiment on ^{233}Th
- Enhancement on top of the GSF extrapolated to low γ energies around 2.5 MeV interpreted as scissors mode resonanance

Scissors Mode in Superheavy ^{254}No

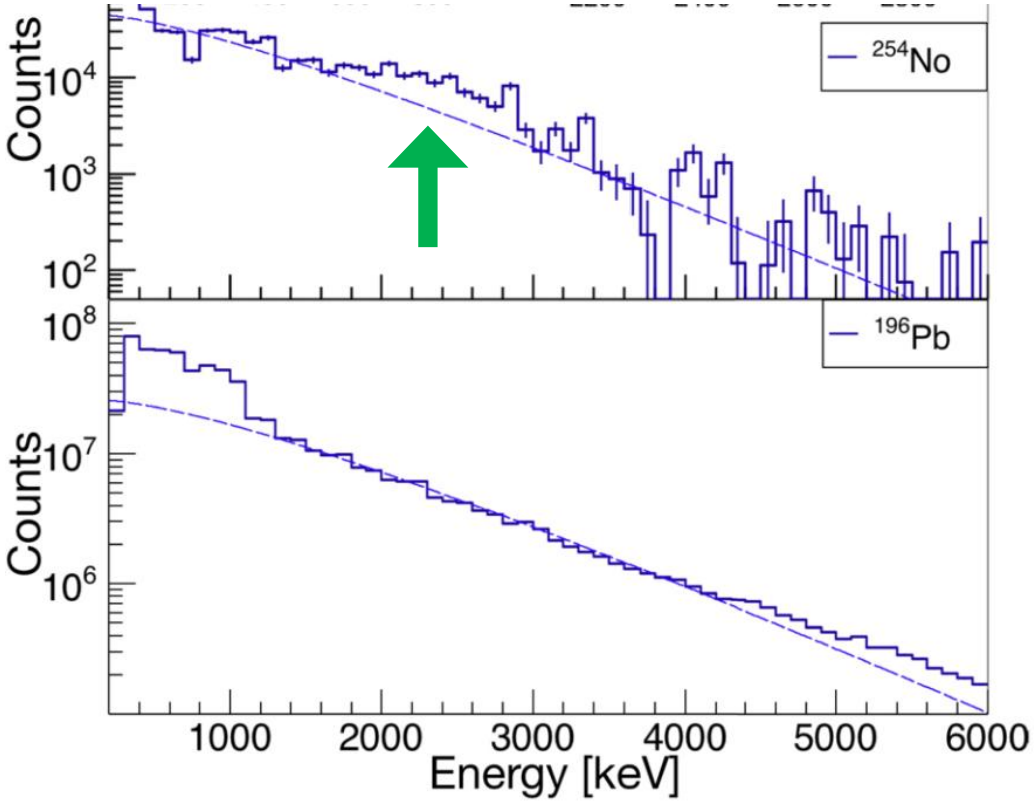
F.L. Bello Garotte et al., Phys. Lett. B 834, 137479 (2022)



- M1 Character demonstrated by polarization measurements

Scissors Mode in Superheavy ^{254}No

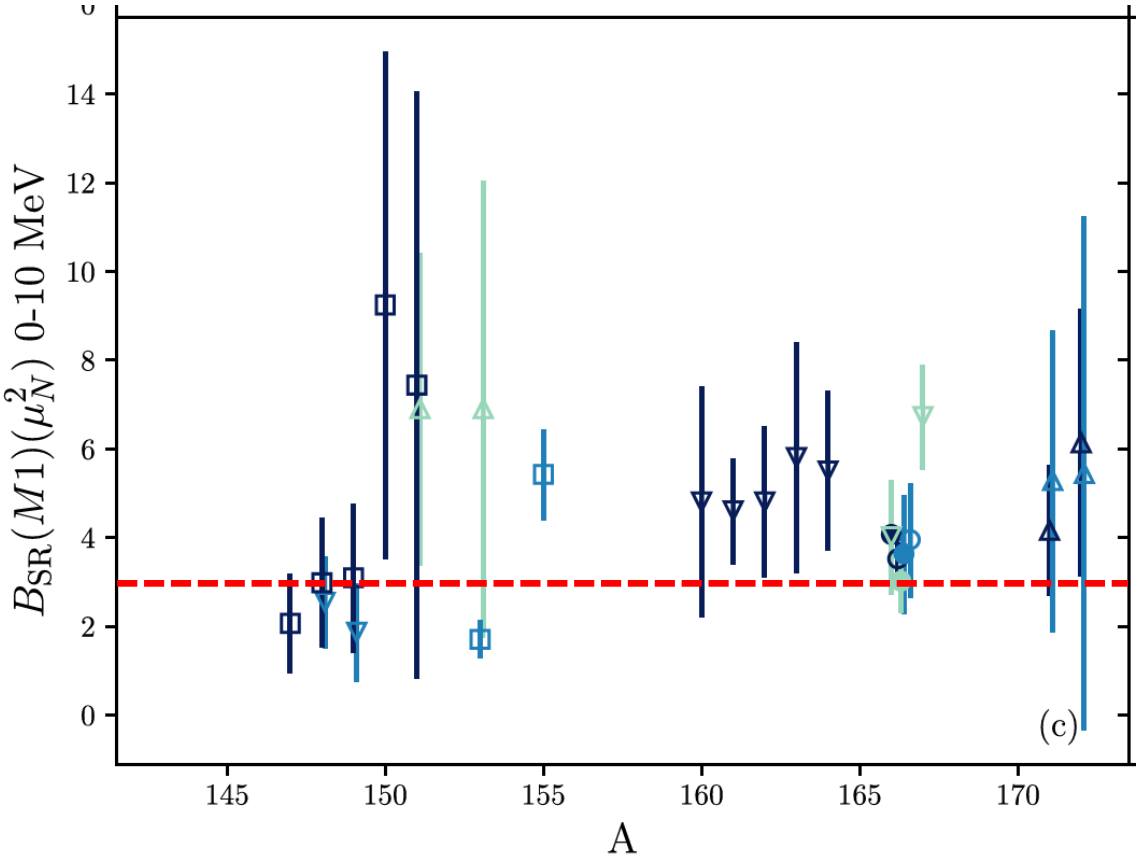
F.L. Bello Garotte et al., Phys. Lett. B 834, 137479 (2022)



- M1 Character demonstrated by polarization measurements

Systematics of Quasicontinuum Strength

F. Pogliano et al., Phys. Rev. C 107, 034605 (2023)



- Large uncertainties but scissors mode strength seems to be higher

GSF of ^{150}Nd from Oslo Experiment

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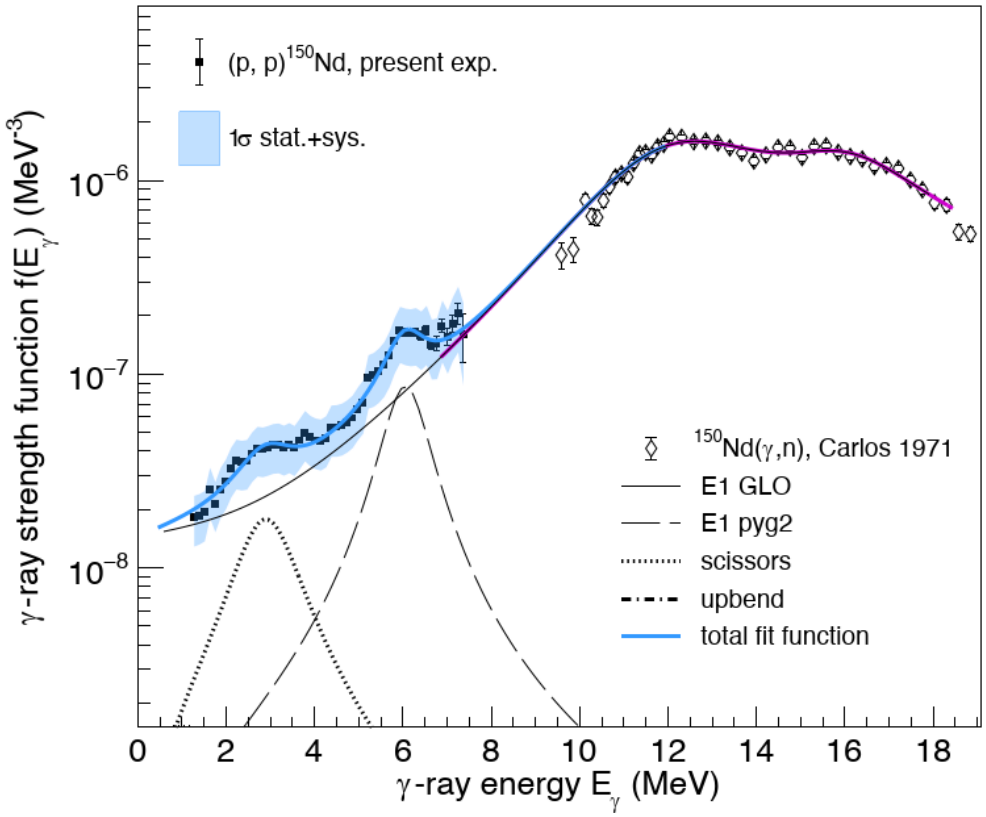
M. Guttormsen et al., Phys. Rev. C 106, 034314 (2022)



- Decomposition into GDR, PDR and Scissors Mode

Independence of Initial and Final States

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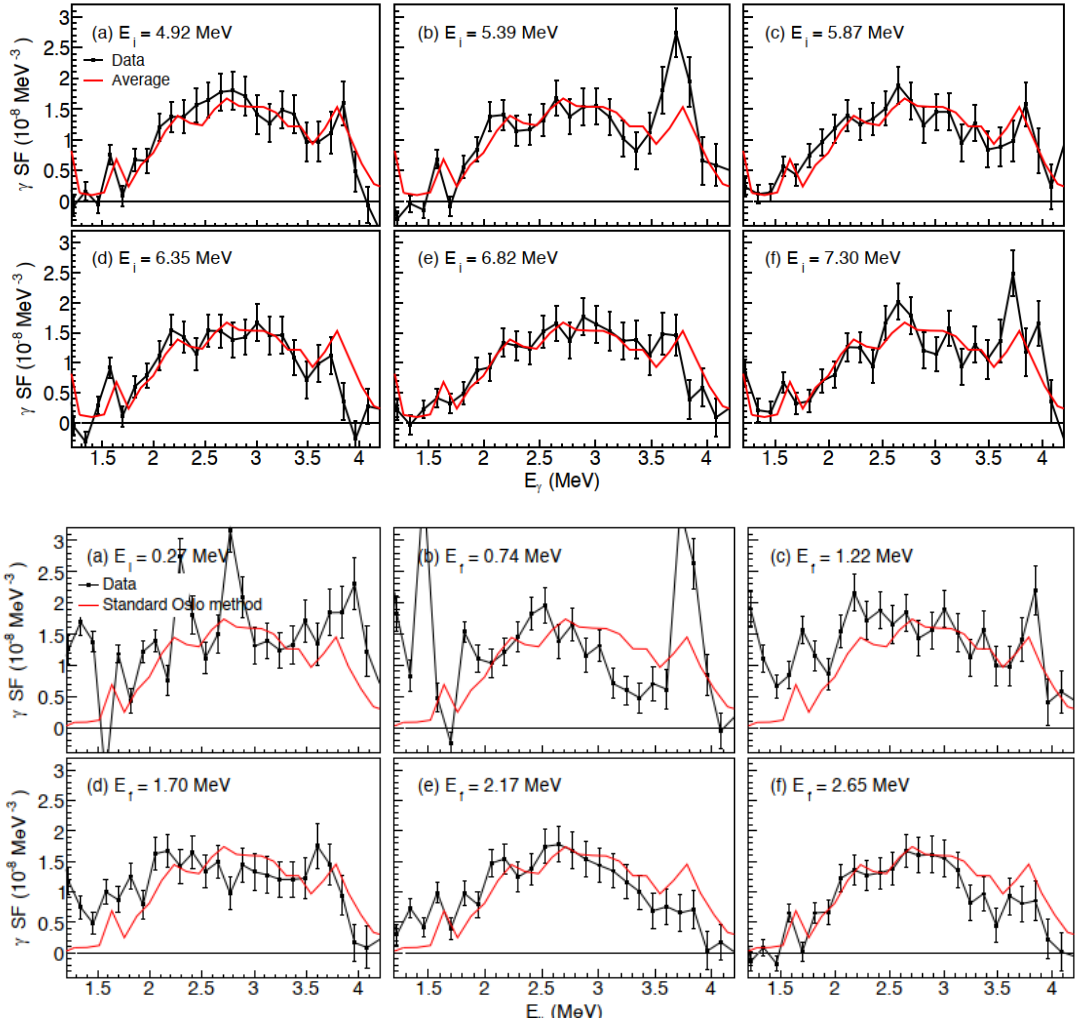


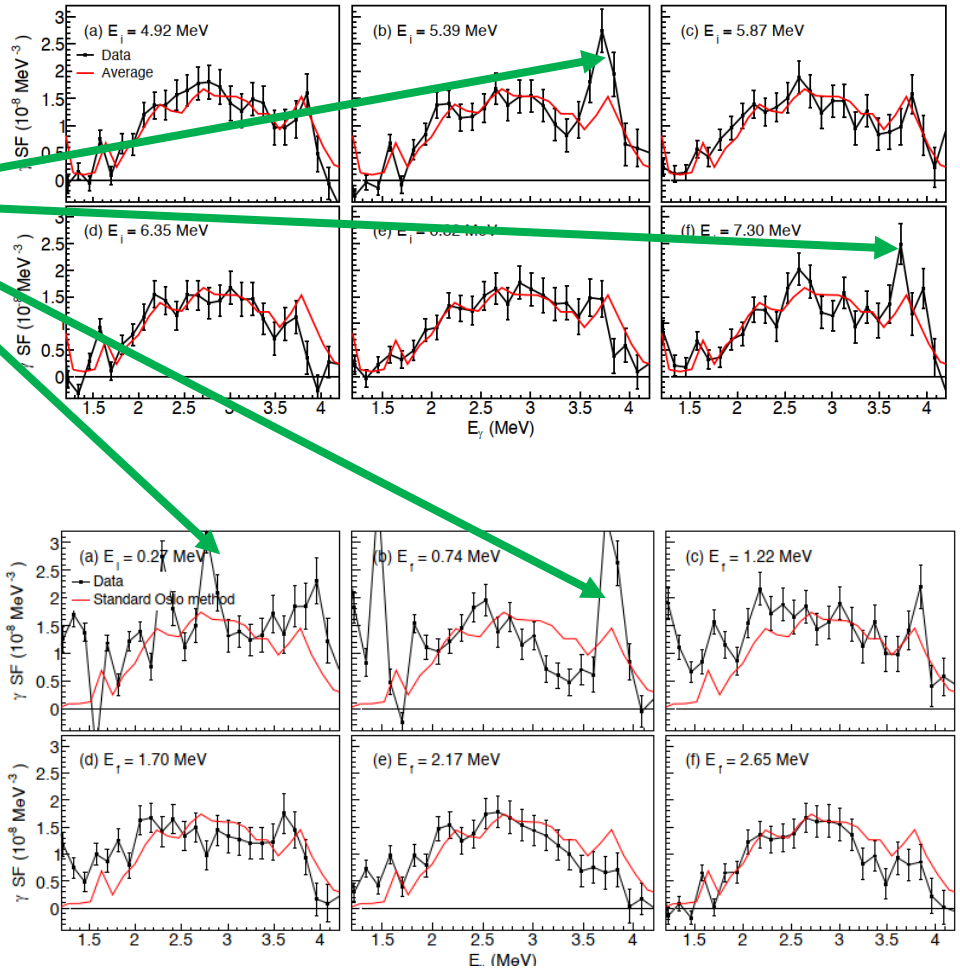
E_i

E_f

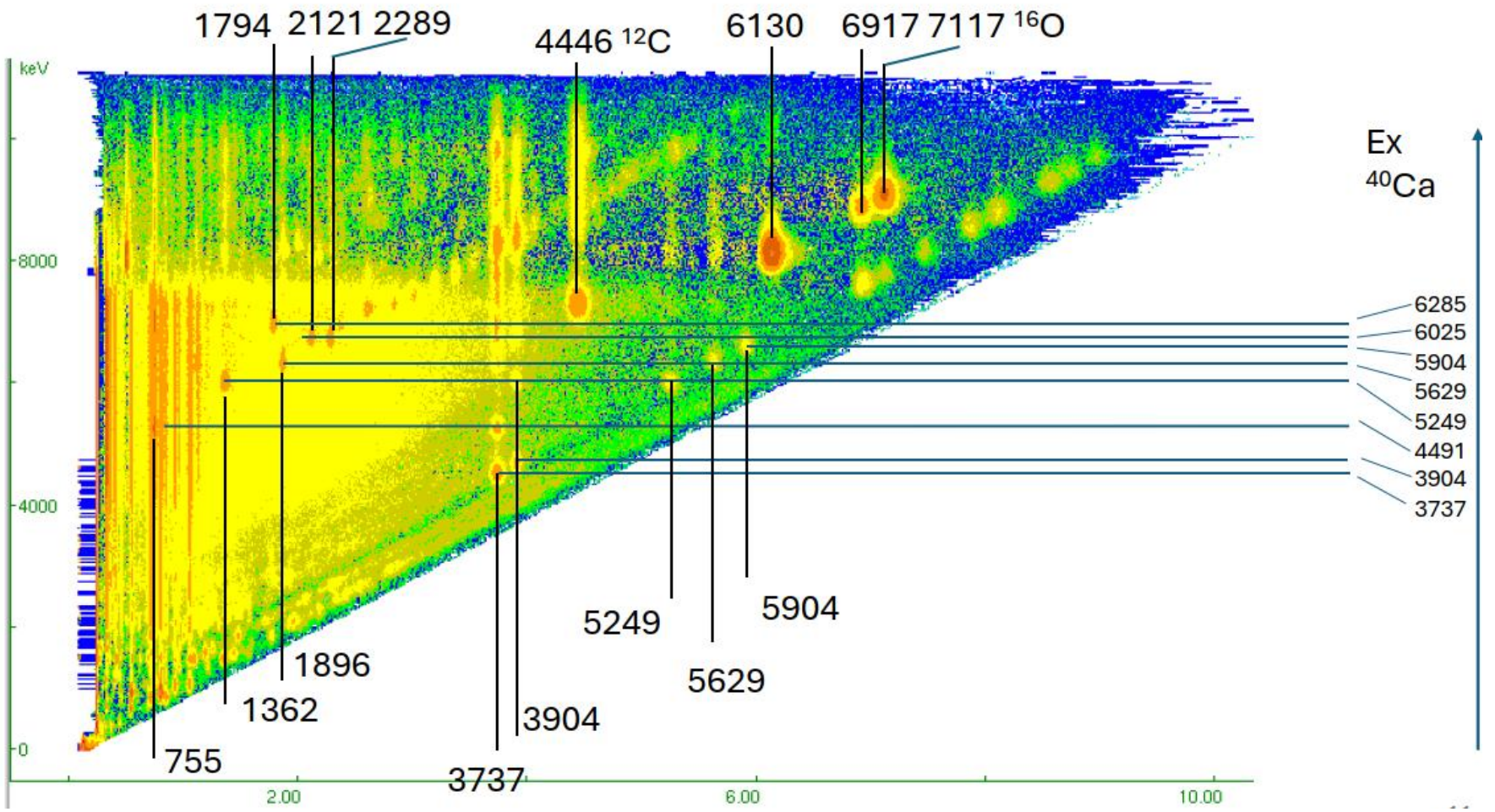
- BA hypothesis fails for $E_f < 2$ MeV

Independence of Initial and Final States

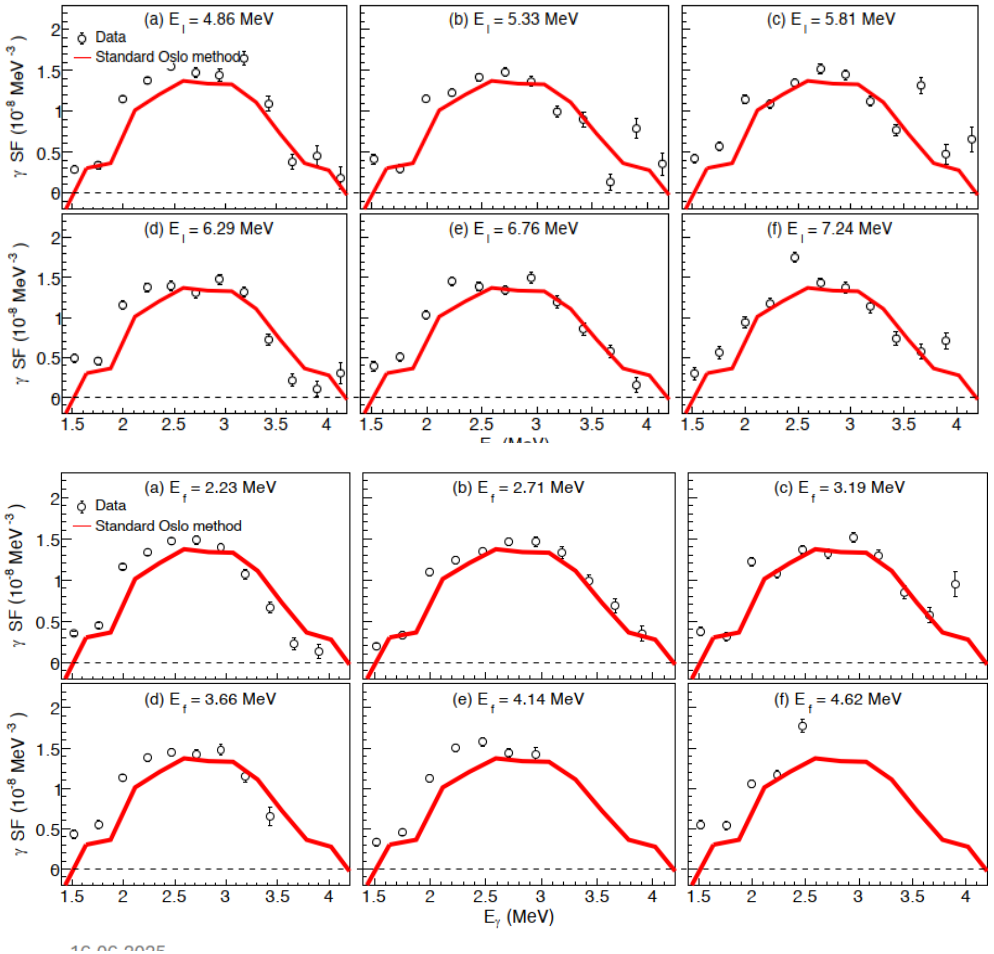
- Conspicuous structures
- BA hypothesis fails for $E_f < 2$ MeV



Contaminants



Scissors Mode in ^{150}Nd Oslo Data



- BA hypothesis holds in the investigated energy range

Scissors Mode Strength in the Quasicontinuum

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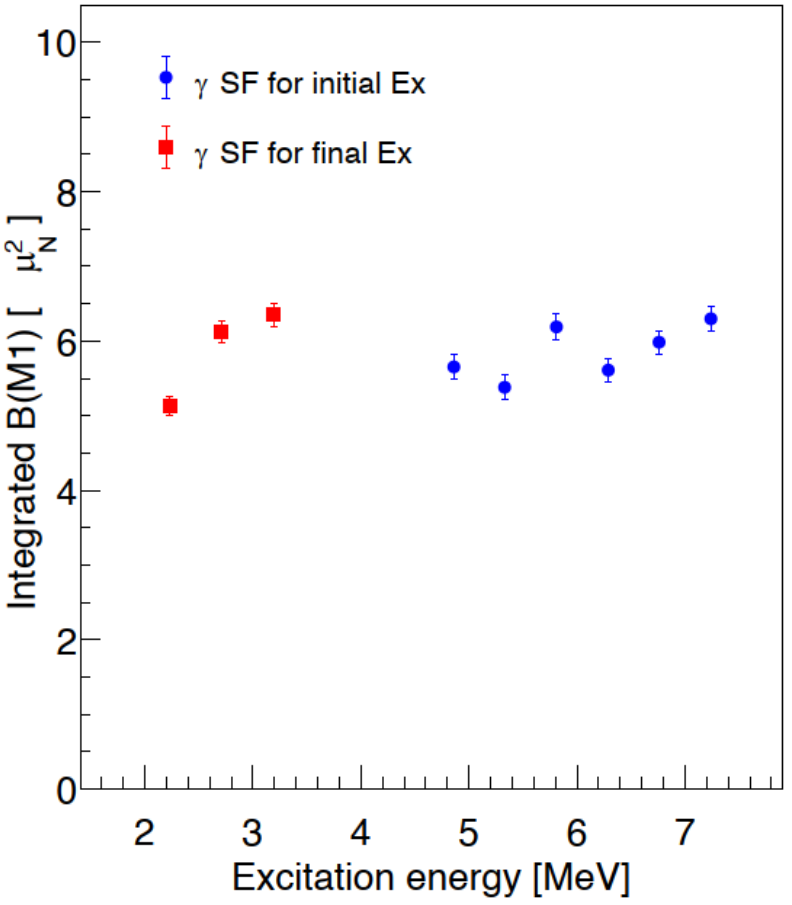
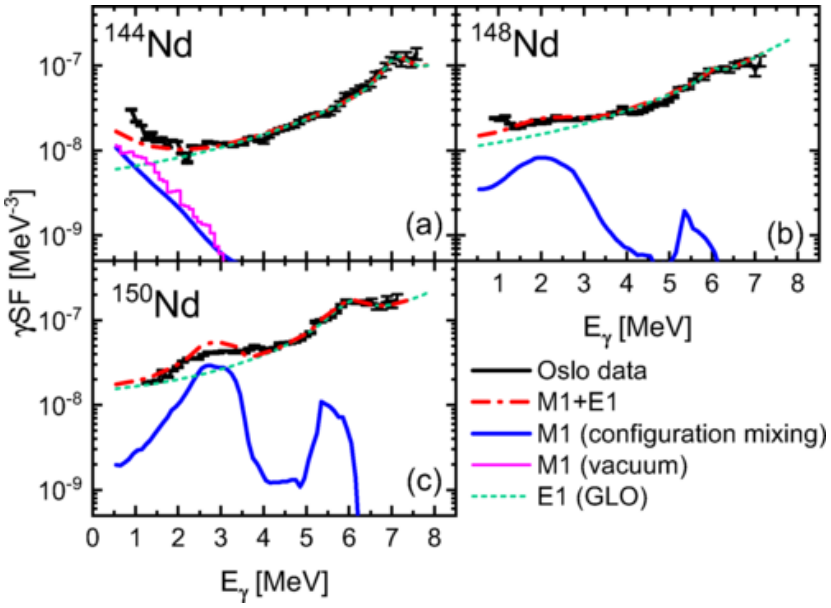
PvNC, M. Guttormsen et al., to be published

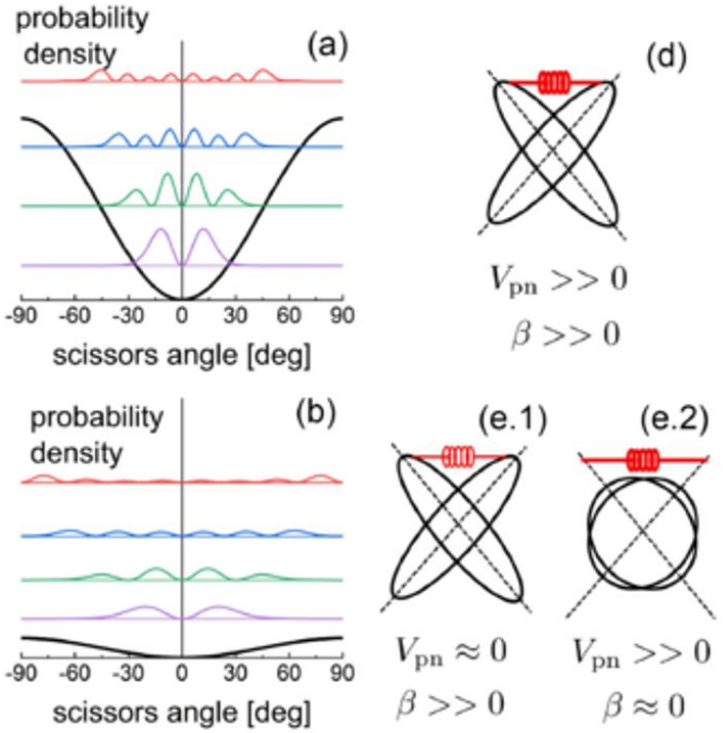
- Scissors mode strength about twice the g.s. value
- Relation to two-phonon structure?
- Moment of inertia about 80% of rigid rotor value



Recent Theoretical Work

F.-Q. Chen et al. Phys. Rev. Lett. 134, 082502 (2025)





- Proton-neutron projected shell model
- Consistent with shift between scissors mode and LEE as function of deformation
- Calculations reproduce value of about 6 μ_N^2

Summary

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- Extraction of the scissors mode in the quasicontinuum of ^{150}Nd from Oslo experiment
- SM strength in the quasicontinuum about twice the ground-state strength
- BA hypothesis holds in the quasicontinuum energy region
- Reproduced by projected proton-neutron shell model calculations
- Relation to two-phonon excitations?