

$E2$ strength of the scissors mode and F -vector quadrupole charges over a shape-phase transition



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9th International Workshop: Quantum Phase Transitions in Nuclei and Many-body Systems

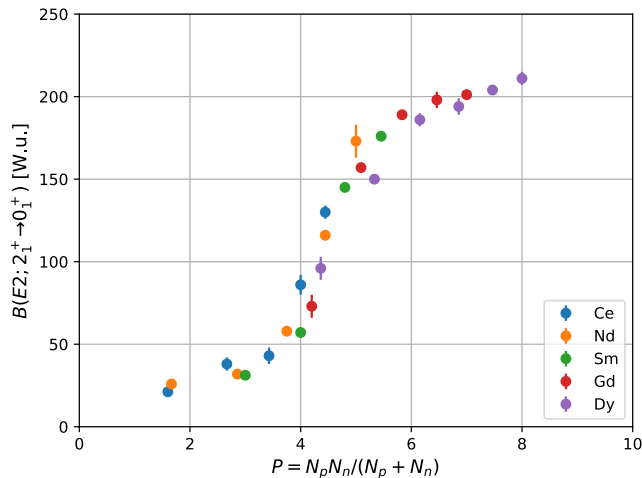
T. Beck*, N. Pietralla, and V. Werner

Institut für Kernphysik, TU Darmstadt, Schlossgartenstr. 9, D-64289 Darmstadt, Germany



Motivation: Evolution of dipole strength in the $A \approx 150$ region

The characteristic evolution of $B(E2)$ strength across the shape transition is not solely explained by an enlargement of the IBM model space.

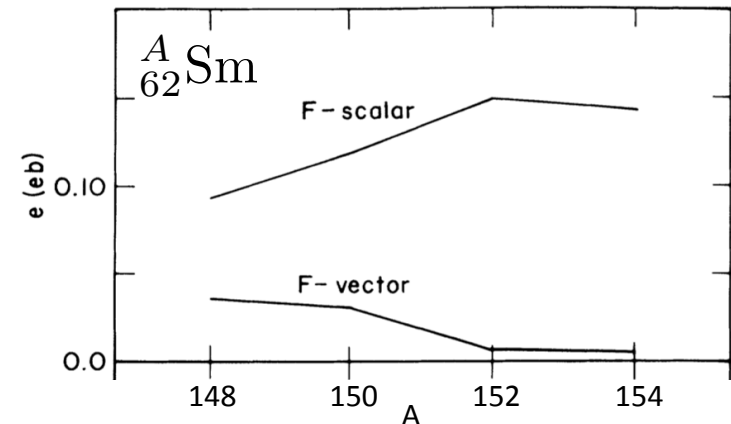


Casten *et al.*, Phys. Rev. Lett. 58 (1987) 658
Casten *et al.*, Phys. Rev. Lett. 82 (1999) 5000

In the dynamical symmetries:

van Isacker *et al.*, Ann. Phys. 171 (1986) 253

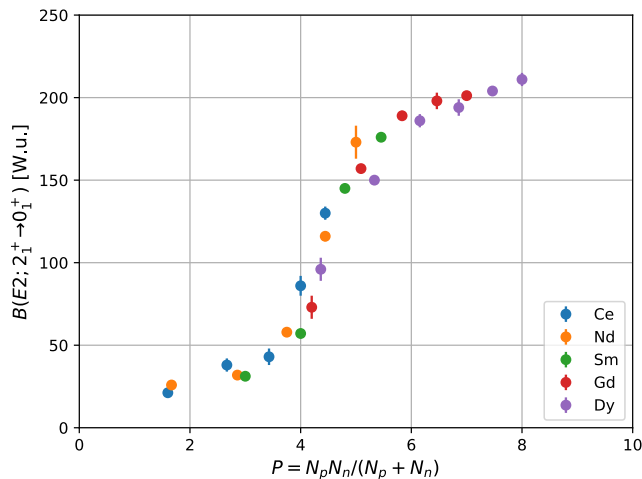
$$B(E2; 2_1^+ \rightarrow 0_1^+) = (e_\nu N_\nu + e_\pi N_\pi)^2 \cdot f_1(N)$$



Otsuka and Ginocchio, Phys. Rev. Lett. 54 (1985) 777

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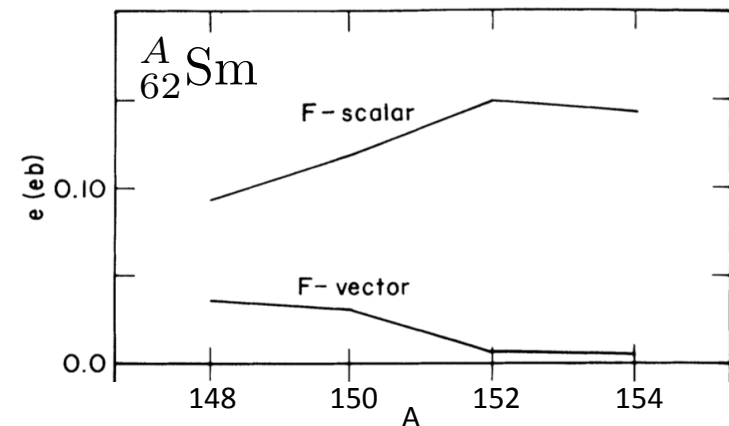
Question:

Does the evolution of the quadrupole boson charges reflect the shape transition?

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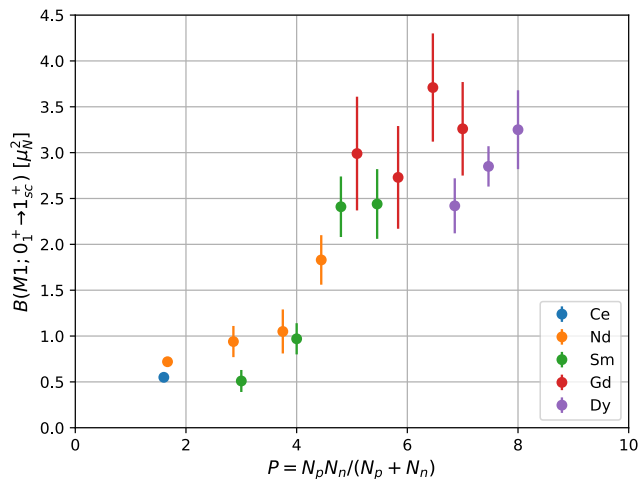
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Pietralla *et al.*, Phys. Rev. C 58 (1998) 184
 Pietralla *et al.*, Phys. Rev. C 52 (1995) R2317
 Enders *et al.*, Phys. Rev. C 71 (2005) 014306

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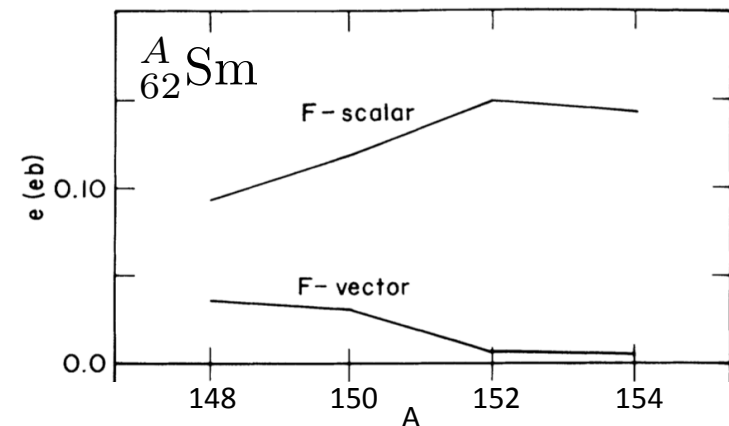
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U(5): $B(E2; 2_{ms}^+ \rightarrow 0_1^+) = (e_\nu - e_\pi)^2 \cdot f_2(N_\nu, N_\pi)$

SU(3): $B(E2; 1_{sc}^+ \rightarrow 2_1^+) = (e_\nu - e_\pi)^2 \cdot f_3(N_\nu, N_\pi)$



Otsuka and Ginocchio, Phys. Rev. Lett. 54 (1985) 777

Experiment: Concept

Based on the well-known properties of the $J^\pi = 1_{sc}^+$ scissors mode state, the electromagnetic decay to the 2_1^+ state is investigated using **Nuclear Resonance Fluorescence**.

Multipole mixing ratio:

Krane *et al.*, At. Data Nucl. Data Tables 11 (1973) 351
Bohr, Mottelson, Nuclear Structure Vol. 1, W.A. Benjamin Inc. (1969)

$$\delta_{1 \rightarrow 2} = \frac{\sqrt{3}}{10} \frac{E_\gamma}{\hbar c} \frac{\langle 2_1^+ || \hat{T}(E2) || 1_{sc}^+ \rangle}{\langle 2_1^+ || \hat{T}(M1) || 1_{sc}^+ \rangle}$$

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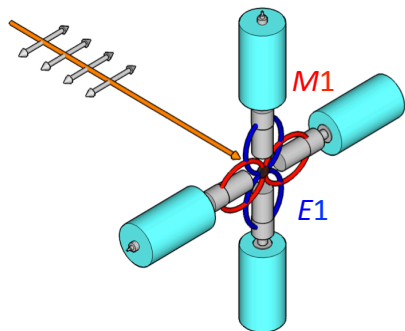
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Utilize the linear polarization of the monochromatic γ -beam of the LCB-facility HI γ S:

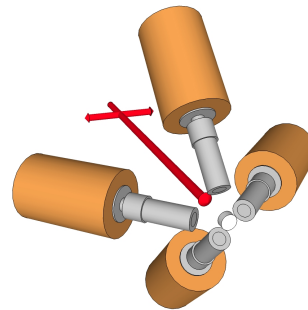
Pietralla *et al.*, Nucl. Instr. Meth. Phys. Res. A 483 (2002) 556

Weller *et al.*, Prog. Part. Nucl. Phys. 62 (2009) 257



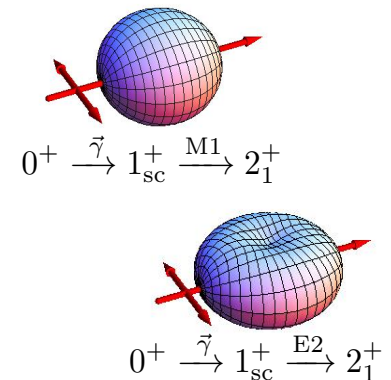
Romig, MSc Thesis, TU Darmstadt (2009)

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Löher *et al.*, Nucl. Instr. Meth. Phys. Res. A 723 (2013) 136

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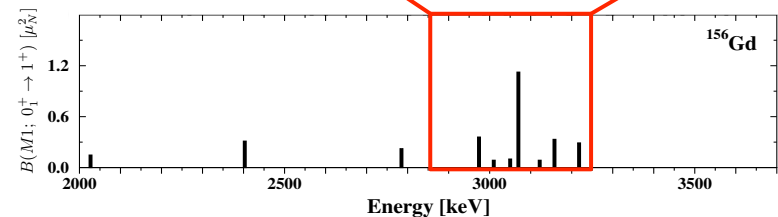
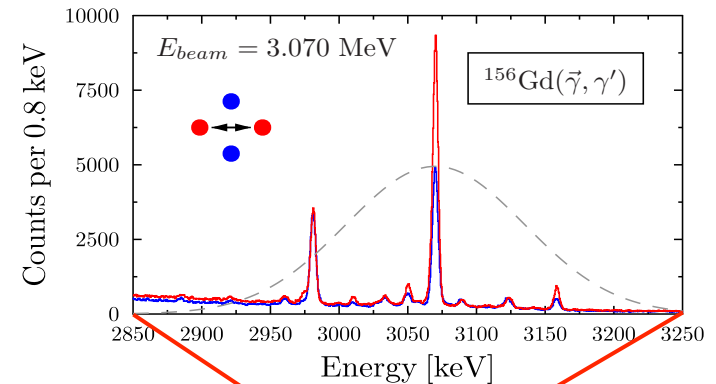
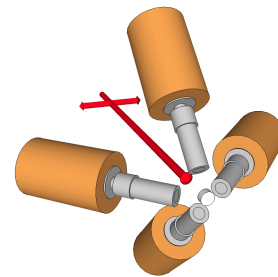
linearly polarized beam

high sensitivity setup

distinction of $M1$ and $E2$

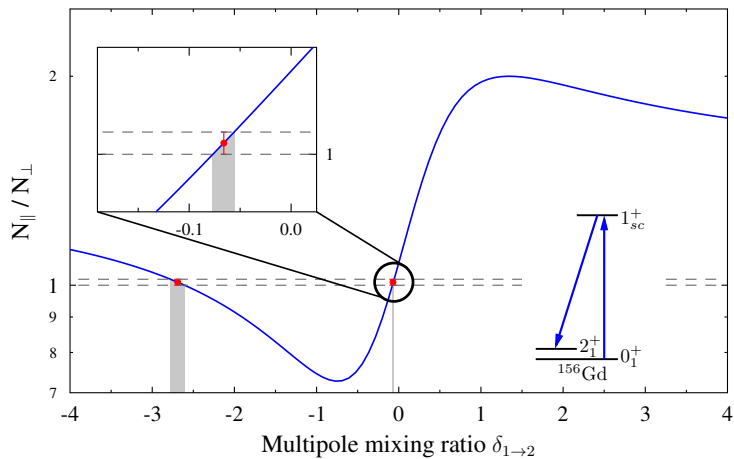
Experiment: Proof of Concept

The method has been applied successfully to the well-deformed rotor ^{156}Gd and enabled the extraction of first information on F -spin changing $E2$ transitions in axially deformed nuclei.

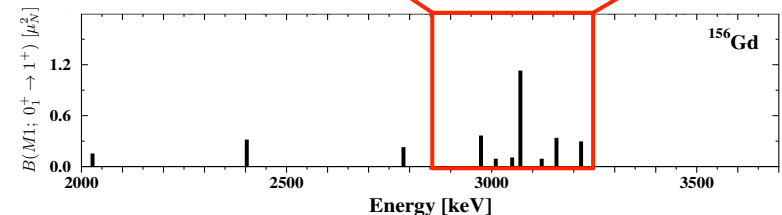
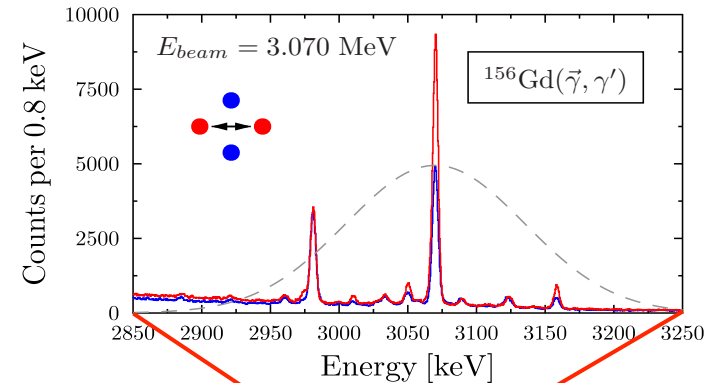
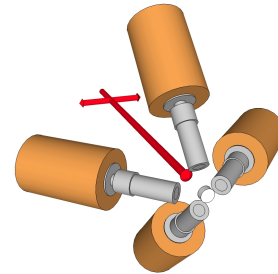


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Beck *et al.*, Phys. Rev. Lett. 118 (2017) 212502

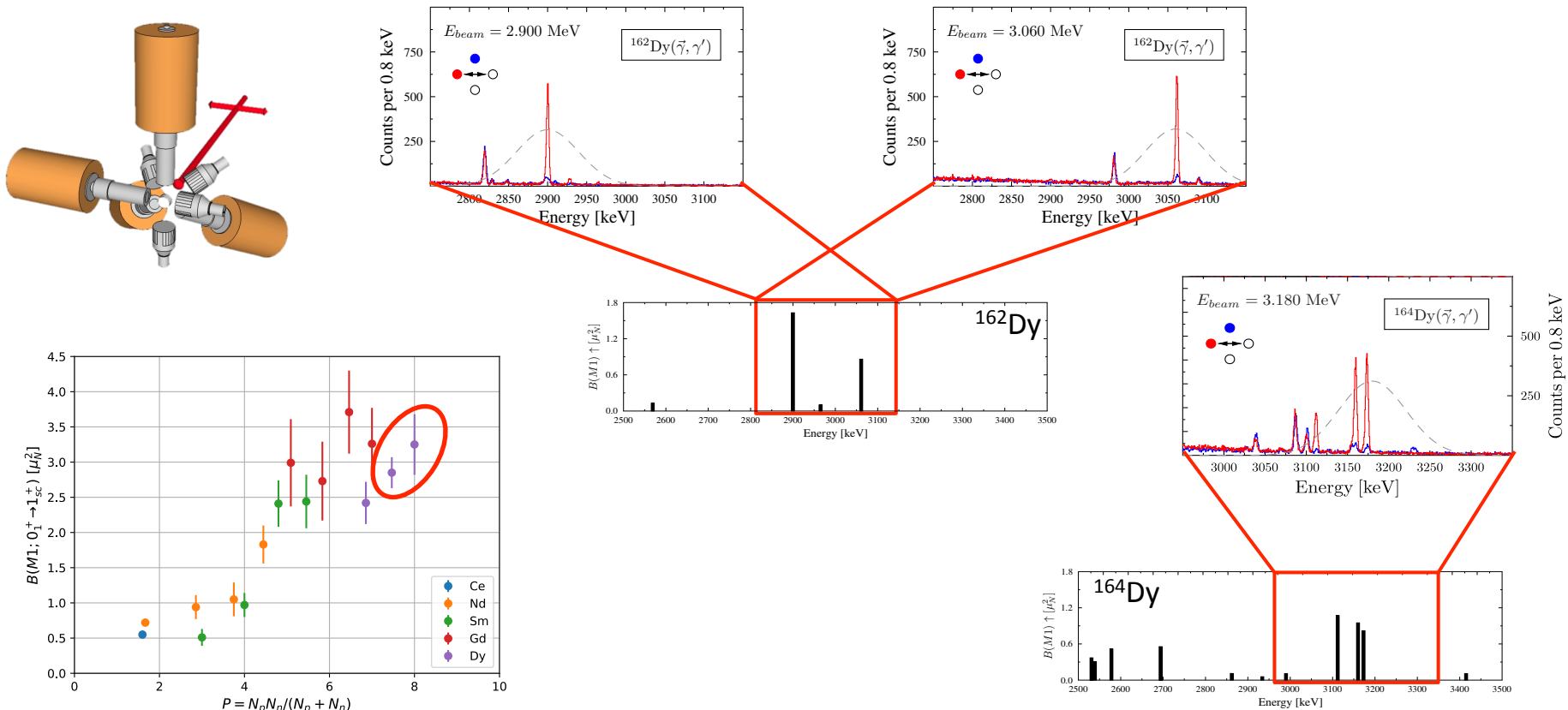


Following an Alaga rule constraint,
this results in

$$\delta_{1 \rightarrow 2} = -0.07(1)_{\text{stat}}(2)_{\text{syst}} \quad \longrightarrow \quad B(E2; 1_{sc}^+ \rightarrow 2_1^+)$$

Experiment: Continuative experiments on $^{162,164}\text{Dy}$

Further experiments have been conducted to apply the developed method and extend it to cases with different detector setups and lower statistics.



Results: Evolution of quadrupole boson charges

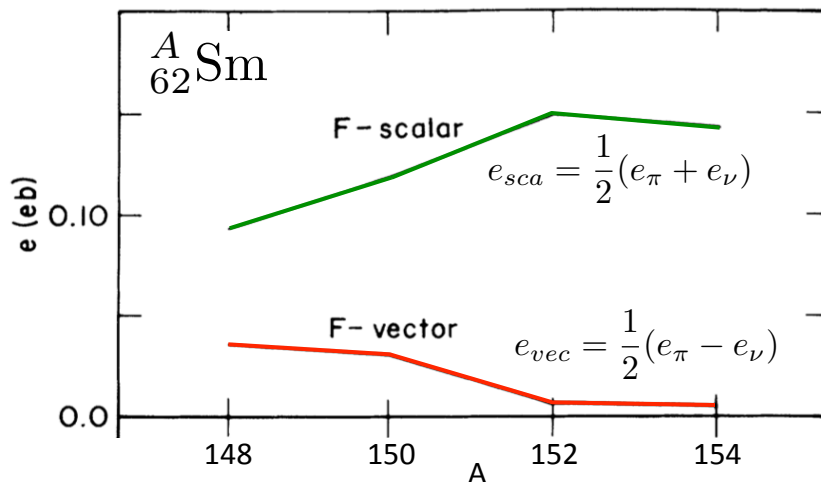
Connection to effective quadrupole boson charges in the F -spin limit of the $U(5)$ and $SU(3)$ dynamical symmetries of the IBM-2:

$$B(E2; 2_1^+ \rightarrow 0_1^+) = (e_\nu N_\nu + e_\pi N_\pi)^2 \cdot f_1(N)$$

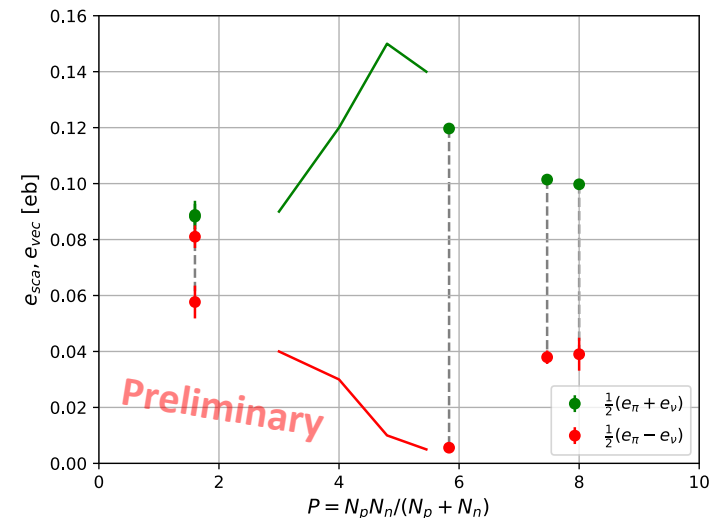
$$B(E2; J_{ms}^+ \rightarrow \tilde{J}^+) = (e_\nu - e_\pi)^2 \cdot f_2(N_\nu, N_\pi)$$

van Isacker *et al.*, Ann. Phys. 171 (1986) 253

Evolution of local boson charges:



Otsuka and Ginocchio, Phys. Rev. Lett. 54 (1985) 777



${}^{142}\text{Ce}$: Vanhoy *et al.*, Phys. Rev. C 52 (1995) 2387

${}^{144}\text{Nd}$: Hicks *et al.*, Phys. Rev. C 57 (1998) 2264

${}^{156}\text{Gd}$: Beck *et al.*, Phys. Rev. Lett. 118 (2017) 212502

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Thank you for your attention!



Federal Ministry
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