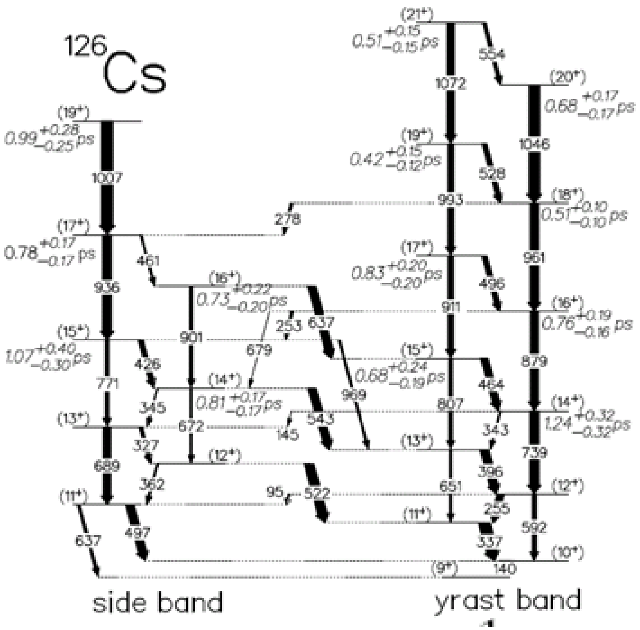
Search for the nuclear chirality



10 minutes manual for experimenters

Ernest Grodner

National Centre for Nuclear Research (OTWOCK)
Heavy Ion Lab. (WARSAW)

Doubling of E, B(M1), B(E2) , …

$$\left[R_Y T, H\right] = 0$$

$$|+\rangle = \frac{1}{\sqrt{2}} \frac{|L\rangle + |R\rangle}{\sqrt{1+\varepsilon}} \qquad \langle + | H | + \rangle = \frac{E_0 + \Delta E}{1+\varepsilon}$$

$$|-\rangle = \frac{i}{\sqrt{2}} \frac{|L\rangle - |R\rangle}{\sqrt{1-\varepsilon}} \qquad \langle - | H | - \rangle = \frac{E_0 - \Delta E}{1-\varepsilon}$$

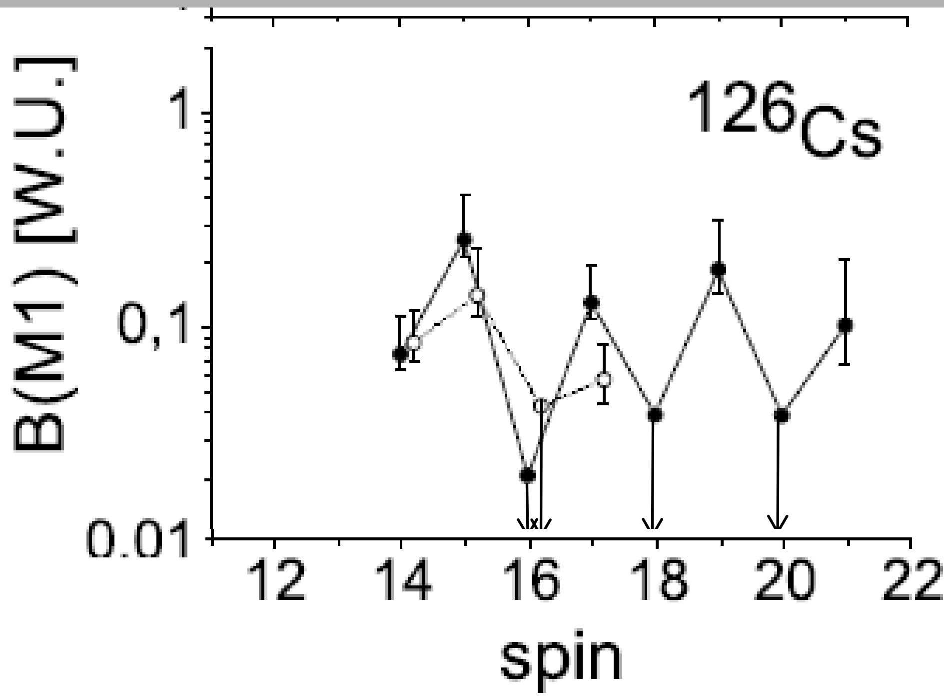
Parameters

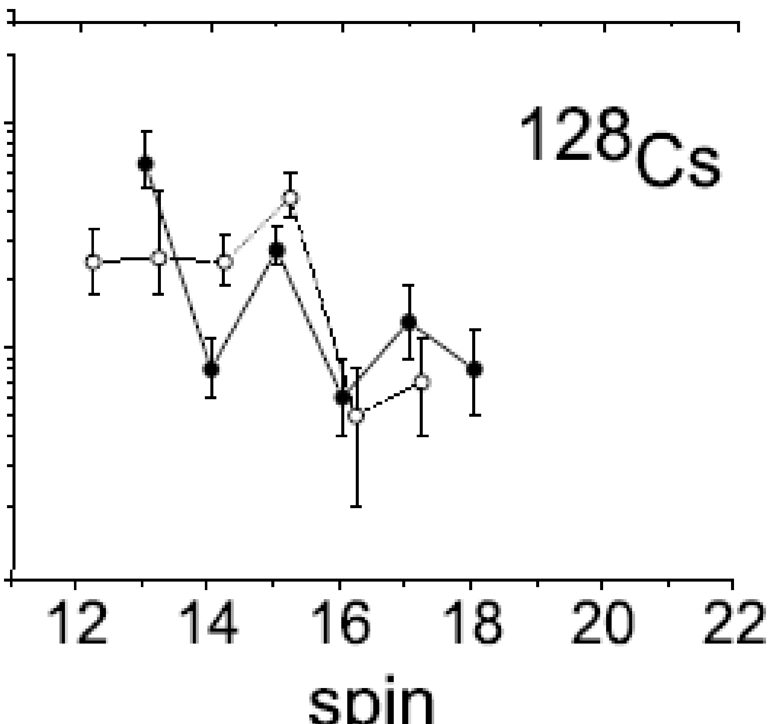
Overlap $\quad \varepsilon = \mathrm{Re}\langle L | R \rangle$

Tunneling effect $\quad \Delta E = \mathrm{Re}\langle L | H | R \rangle$

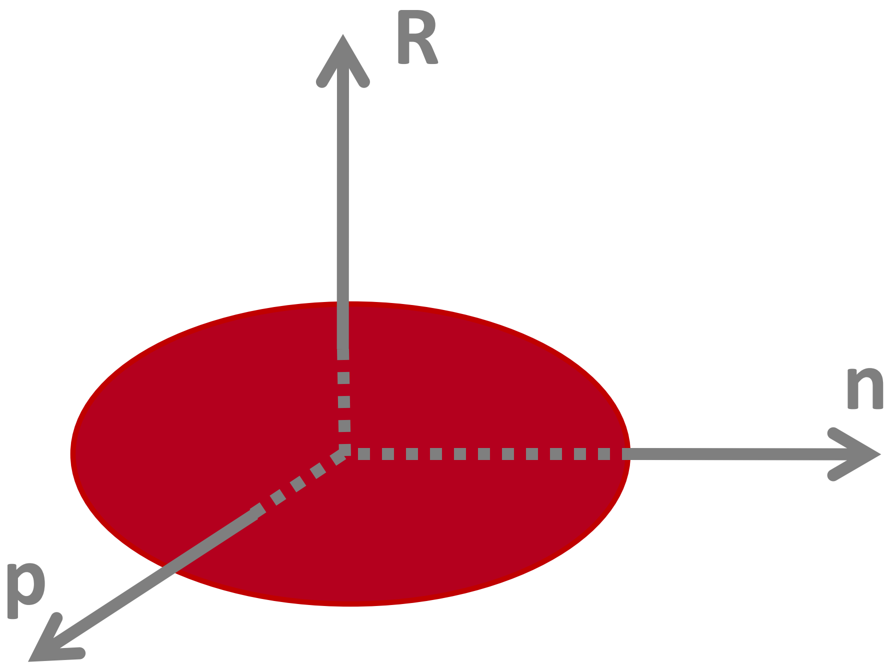
Diagonal mat. element $\quad E_0 = \mathrm{Re}\langle L | H | L \rangle$

Doubling of E, B(M1), B(E2) , …





Patterns – signature staggering

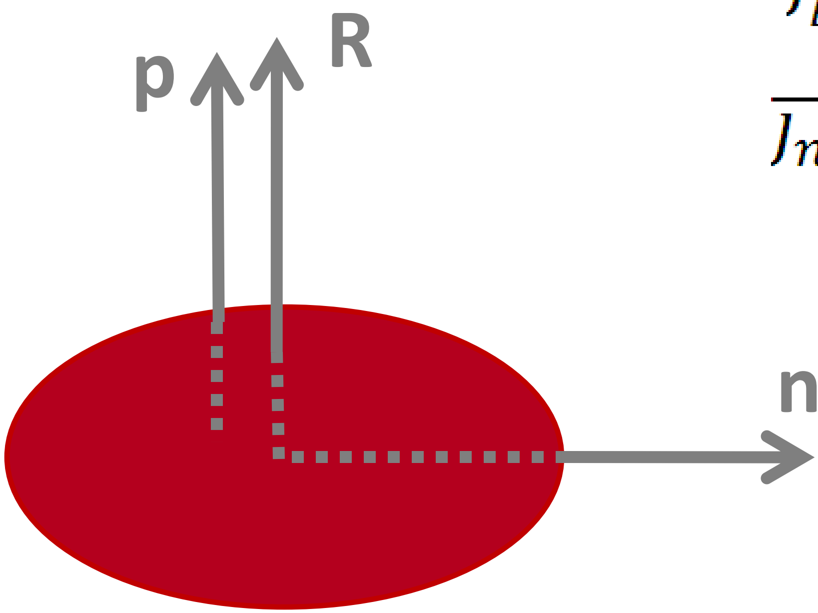


$$\overrightarrow{J_p} \cdot \overrightarrow{J_R} = 0$$

$$\overrightarrow{J_n} \cdot \overrightarrow{J_R} = 0$$

$$\vec{I} \cdot \vec{\omega} = 0$$

Patterns – signature staggering

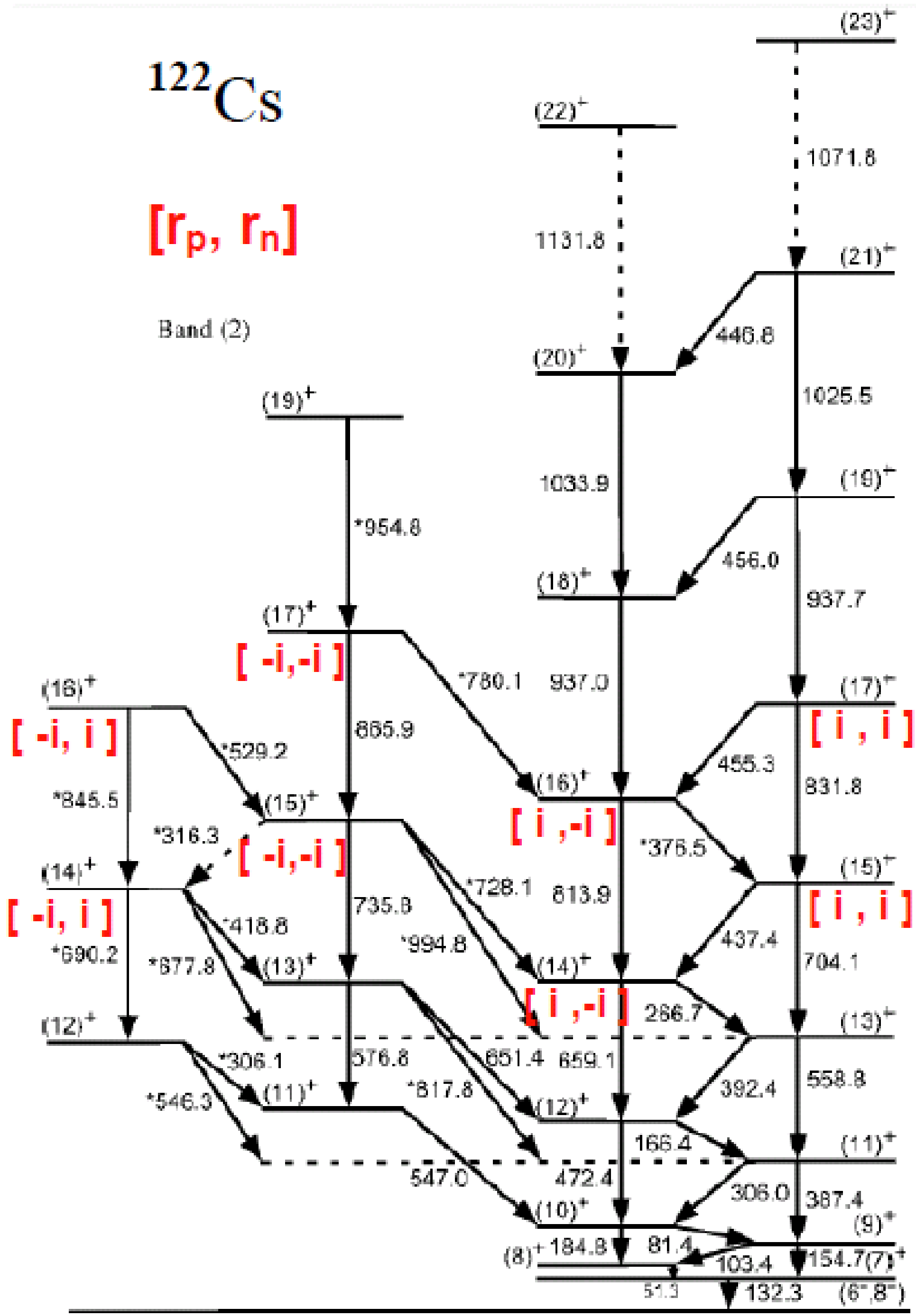


$$\overrightarrow{J_p} \cdot \overrightarrow{J_R} \neq 0$$

Large energy splitting for |I,M> and |I,-M> substates

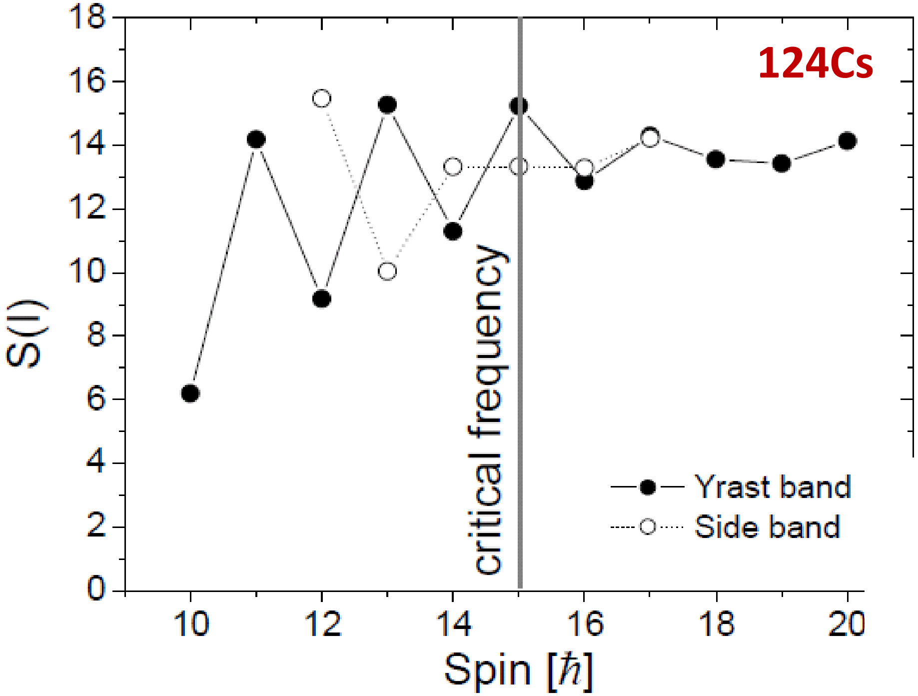
$$\overrightarrow{J_n} \cdot \overrightarrow{J_R} \neq 0$$

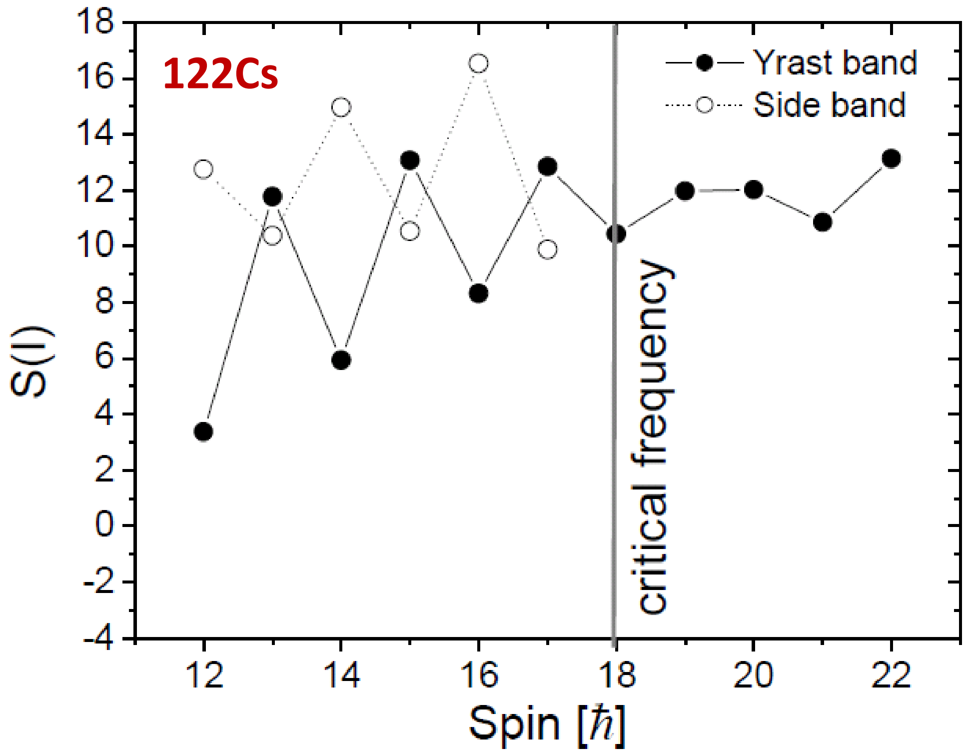
Small energy splitting



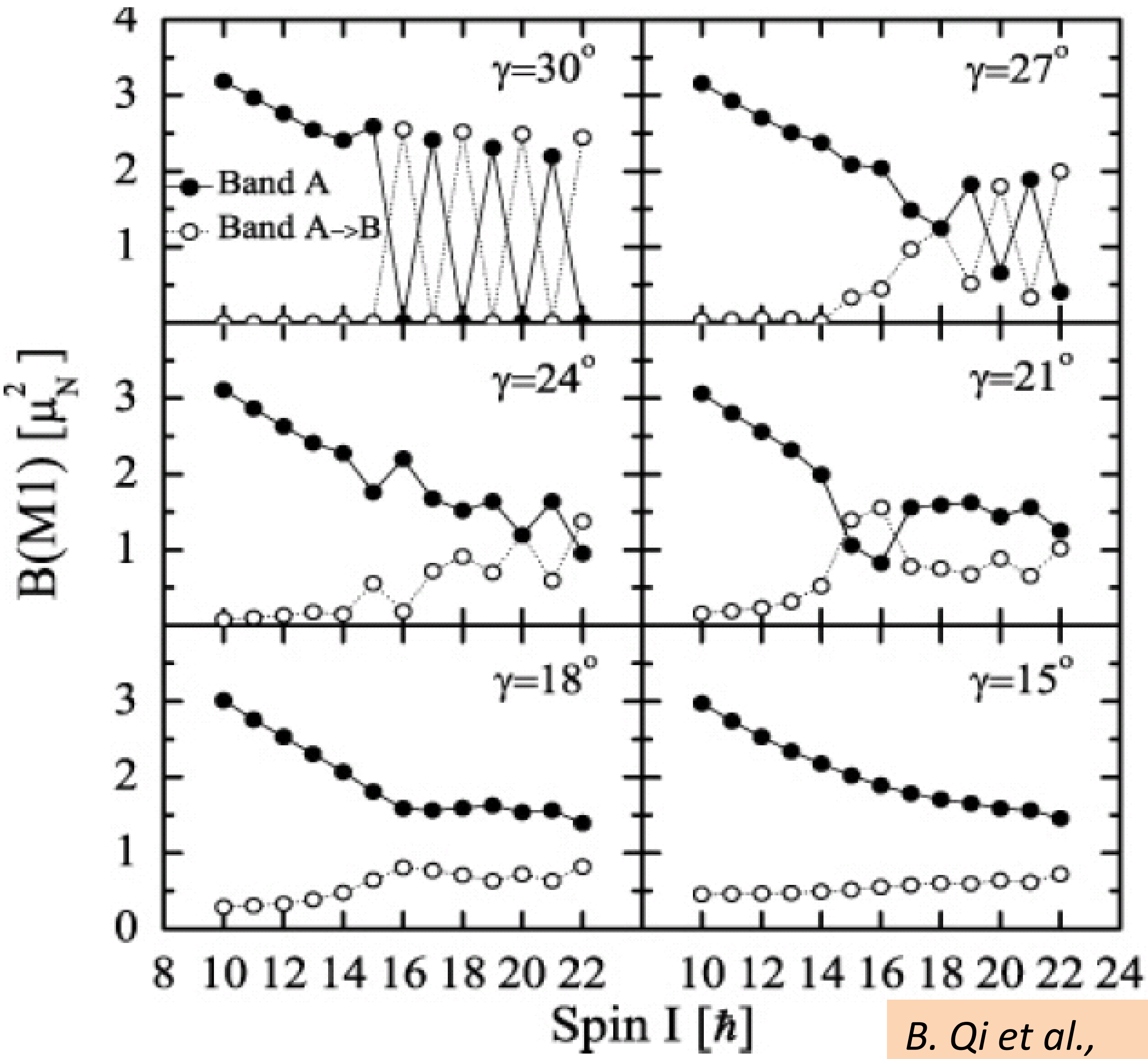
total signature	r_p	r_n	r_c	spin sequence
-1	i	i	1	1, 3, 5, 7, ...
1	i	-i	1	0, 2, 4, 6, ...
-1	-i	-i	1	1, 3, 5, 7, ...
1	-i	i	1	0, 2, 4, 6, ...

Patterns – signature staggering



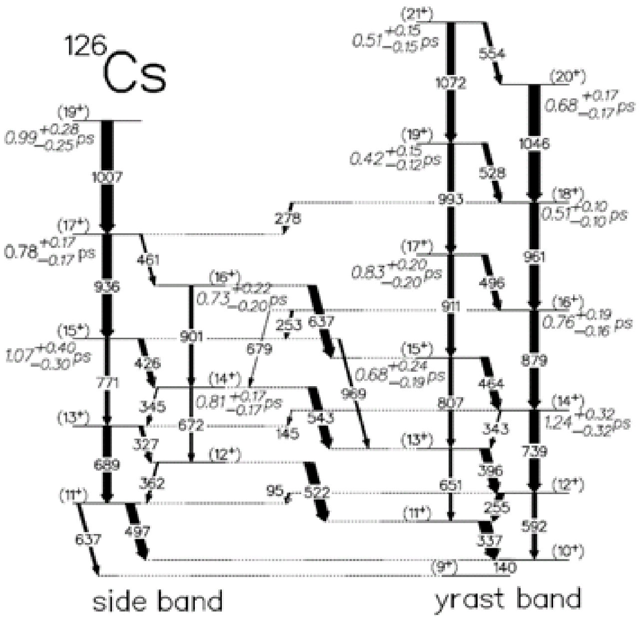


Chiral bands talk opposite values



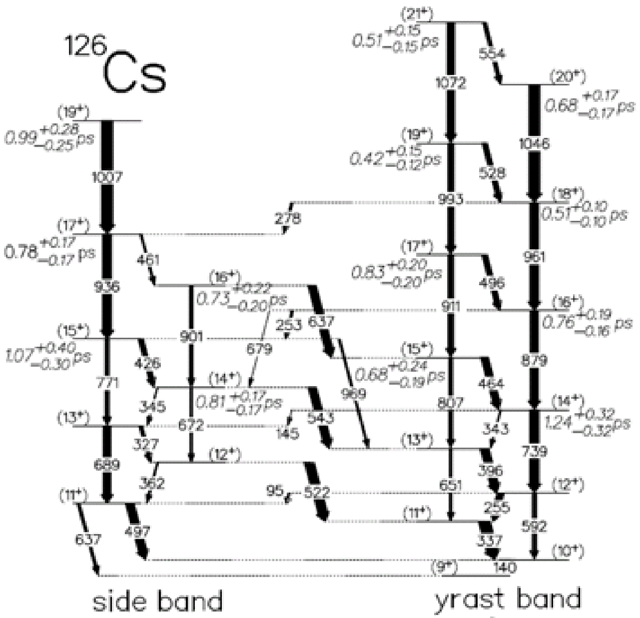
B. Qi et al.,

PHYSICAL REVIEW C 79, 041302(R) (2009)



$$|I,M,+\rangle = \frac{1}{\sqrt{2}N_{I+}}\left(|I,M,L\rangle + |I,M,R\rangle\right)$$

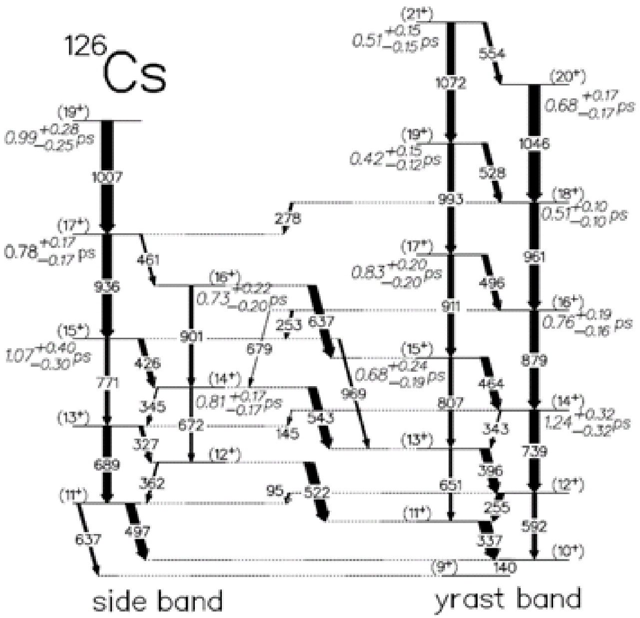
$$|I,M,-\rangle = \frac{i}{\sqrt{2}N_{I-}}\left(|I,M,L\rangle - |I,M,R\rangle\right)$$



$$|I, M, +\rangle = \frac{1}{\sqrt{2}N_{I+}}(|I, M, L\rangle + |I, M, R\rangle)$$

$$|I, M, -\rangle = \frac{i}{\sqrt{2}N_{I-}}(|I, M, L\rangle - |I, M, R\rangle)$$

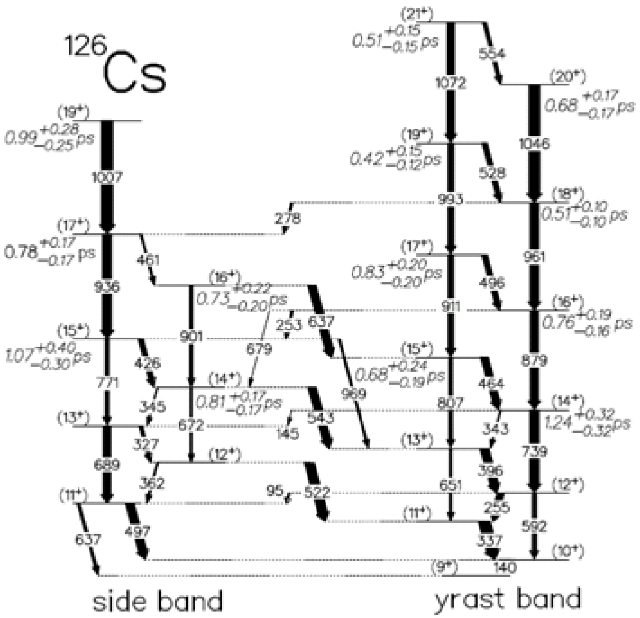
$$\langle I_2, + \| M \| I_1, + \rangle = \frac{1}{\sqrt{2}N_{I_2+}}(\langle I_2, L| + \langle I_2, R|)\,|M|\,\frac{1}{\sqrt{2}N_{I_2+}}(|I_1, L\rangle + |I_1, R\rangle)$$



$$|I, M, +\rangle = \frac{1}{\sqrt{2}N_{I+}}(|I, M, L\rangle + |I, M, R\rangle)$$

$$|I, M, -\rangle = \frac{i}{\sqrt{2}N_{I-}}(|I, M, L\rangle - |I, M, R\rangle)$$

$$\langle I_2, +\|M\|I_1, +\rangle = \frac{1}{2N_{I_2+}N_{I_1+}}(\langle I_2, L\|M\|I_1, L\rangle + \langle I_2, R\|M\|I_1, R\rangle + \langle I_2, L\|M\|I_1, R\rangle + \langle I_2, R\|M\|I_1, L\rangle)$$

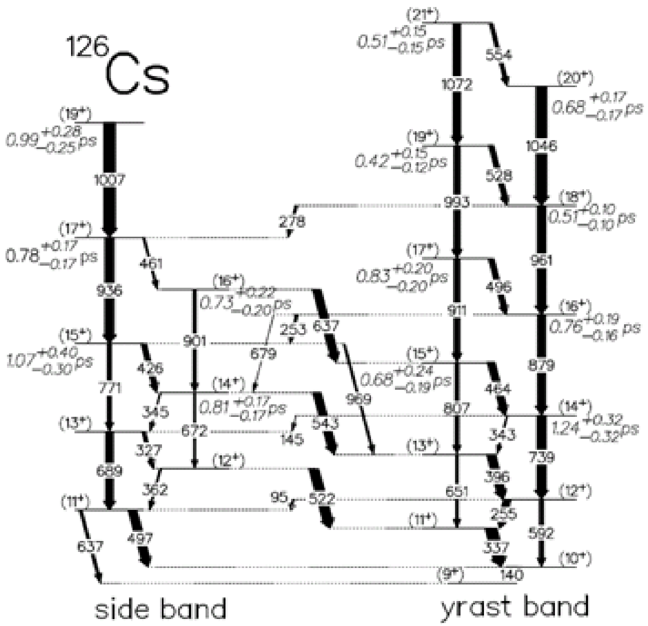


$$|I,M,+\rangle = \frac{1}{\sqrt{2}N_{I+}}\left(|I,M,L\rangle + |I,M,R\rangle\right)$$

$$|I,M,-\rangle = \frac{i}{\sqrt{2}N_{I-}}\left(|I,M,L\rangle - |I,M,R\rangle\right)$$

$$\langle L|M|R\rangle^* = \langle R|M|L\rangle$$

$$\langle I_2,+\|M\|I_1,+\rangle = \frac{1}{2N_{I_2+}N_{I_1+}}\left(\langle I_2,L\|M\|I_1,L\rangle + \langle I_2,R\|M\|I_1,R\rangle + \langle I_2,L\|M\|I_1,R\rangle + \langle I_2,R\|M\|I_1,L\rangle\right)$$



$$|I, M, +\rangle = \frac{1}{\sqrt{2}N_{I+}}(|I, M, L\rangle + |I, M, R\rangle)$$

$$|I, M, -\rangle = \frac{i}{\sqrt{2}N_{I-}}(|I, M, L\rangle - |I, M, R\rangle)$$

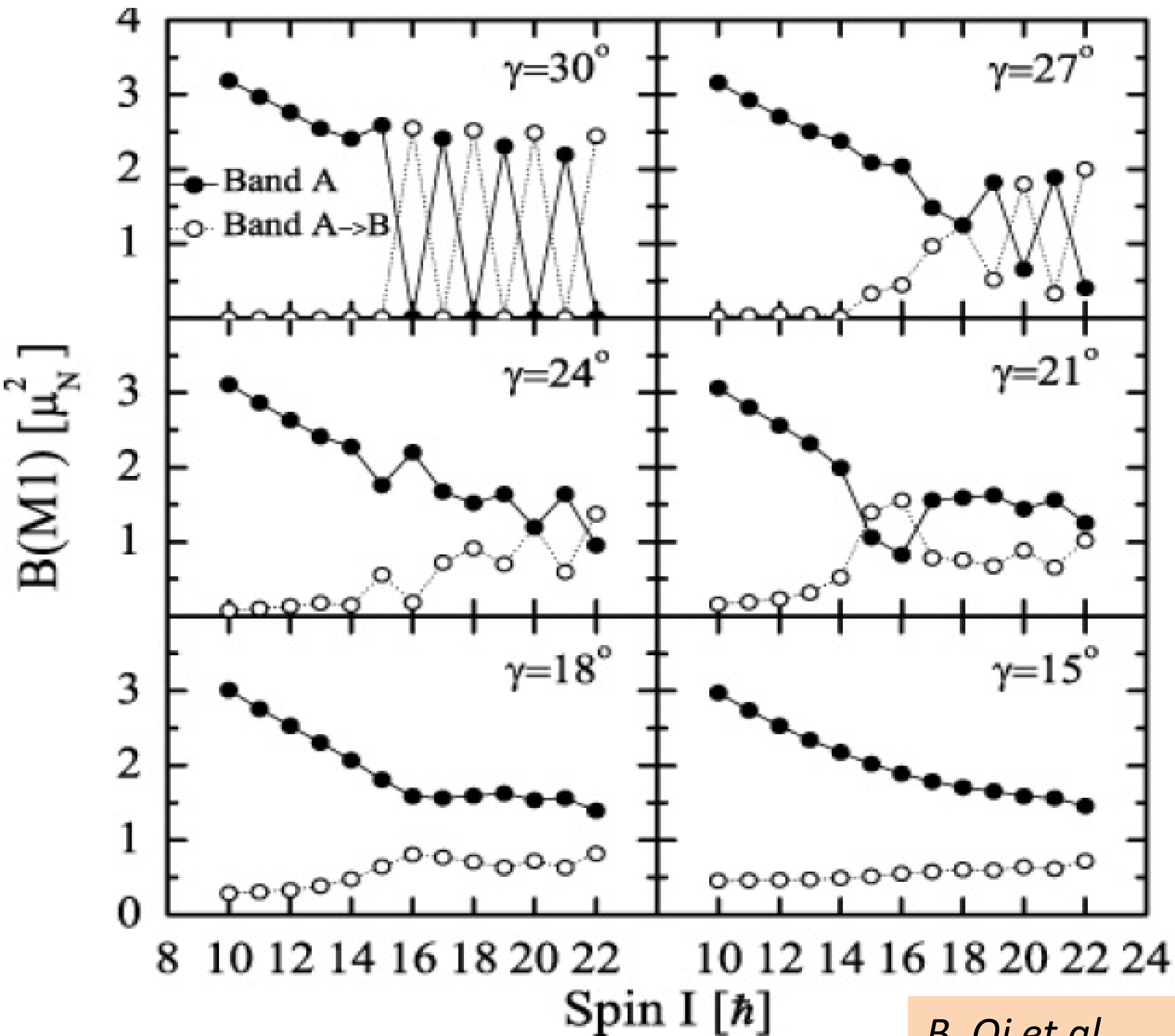
$$\langle L|M|R\rangle^* = \langle R|M|L\rangle$$

$$\langle I_2, +\|M\|I_1, +\rangle = Re\langle I_2, L\|M\|I_1, L\rangle$$

$$\langle I_2, -\|M\|I_1, -\rangle = Re\langle I_2, L\|M\|I_1, L\rangle$$

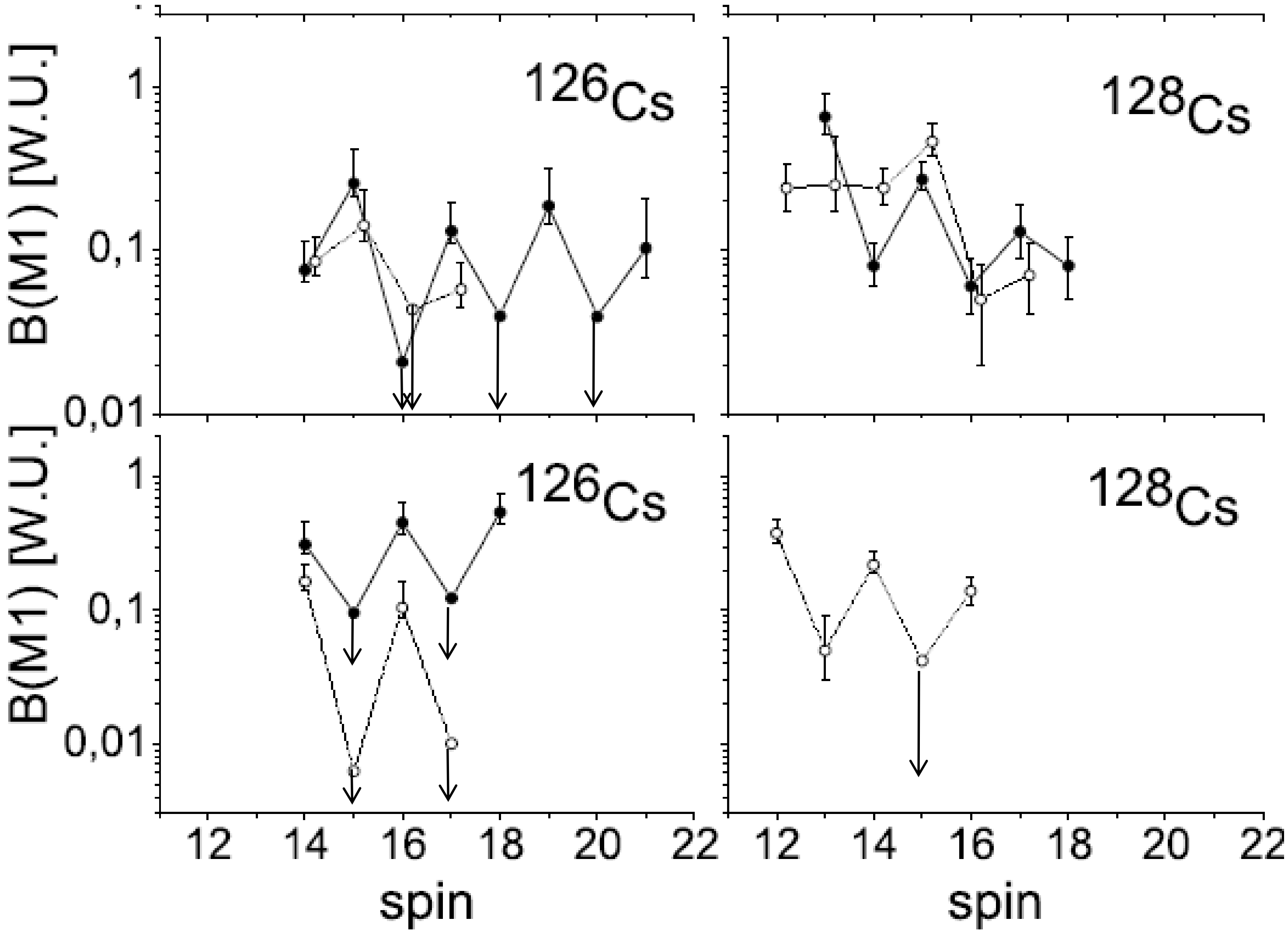
$$\langle I_2, +\|M\|I_1, -\rangle = Im\langle I_2, L\|M\|I_1, L\rangle$$

$$\langle I_2, -\|M\|I_1, +\rangle = Im\langle I_2, L\|M\|I_1, L\rangle$$



B. Qi et al.,
PHYSICAL REVIEW C 79, 041302(R) (2009)

EM selection rules



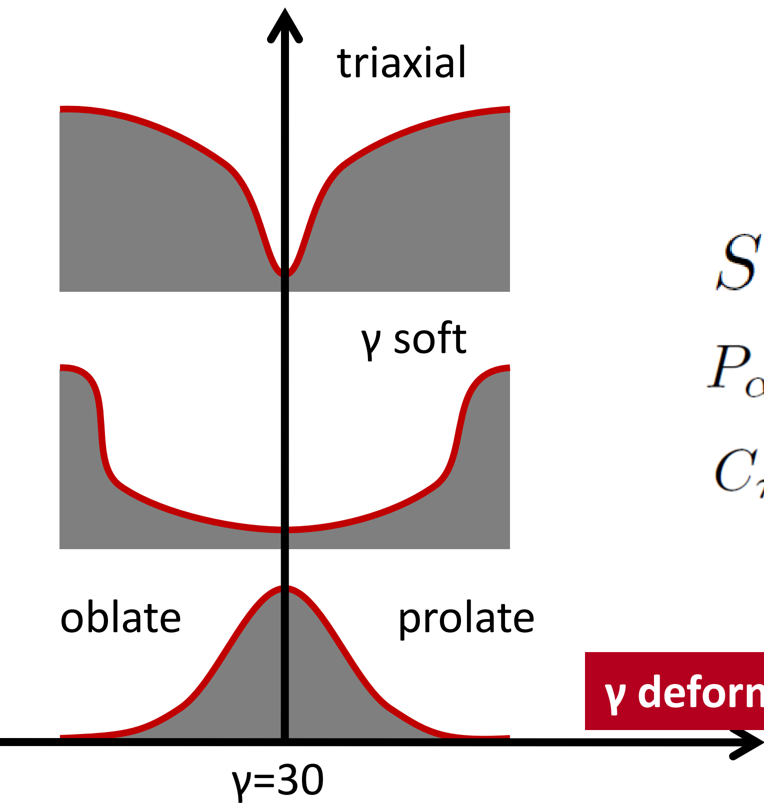
EM selection rules

VOLUME 93, NUMBER 17 PHYSICAL REVIEW LETTERS week ending 22 OCTOBER 2004

Chiral Bands, Dynamical Spontaneous Symmetry Breaking, and the Selection Rule for Electromagnetic Transitions in the Chiral Geometry

T. Koike,[1] K. Starosta,[1,2] and I. Hamamoto[3,4]

Def. potential



Vol. 42 (2011) ACTA PHYSICA POLONICA B No 3–4

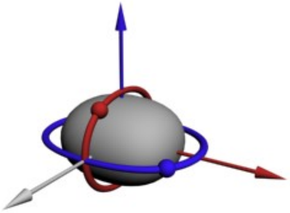
A SYMMETRY OF THE CPHC MODEL OF ODD–ODD NUCLEI AND ITS CONSEQUENCES FOR PROPERTIES OF $M1$ AND $E2$ TRANSITIONS*

L. PRÓCHNIAK

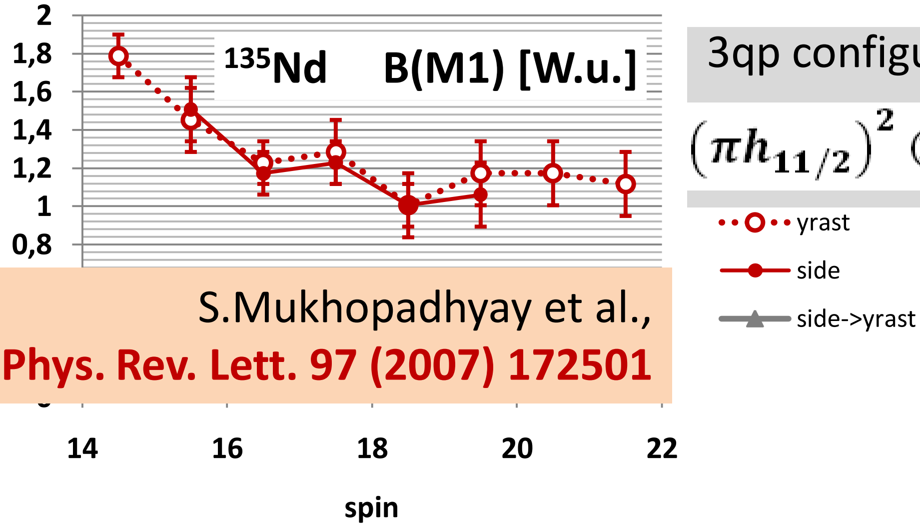
$$S = P_\alpha C_{\pi\nu}$$

$$P_\alpha \alpha_\mu = -\alpha_\mu \,, \qquad \mu = -2, \ldots, 2$$

$$C_{\pi\nu}|(\pi, j_\pi m_\pi)(\nu, j_\nu m_\nu)\rangle = |(\pi, j_\nu m_\nu)(\nu, j_\pi m_\pi)\rangle$$



EM selection rules



S.Mukhopadhyay et al.,
Phys. Rev. Lett. 97 (2007) 172501

3qp configuration

$$(\pi h_{11/2})^2 \otimes \nu h_{11/2}$$

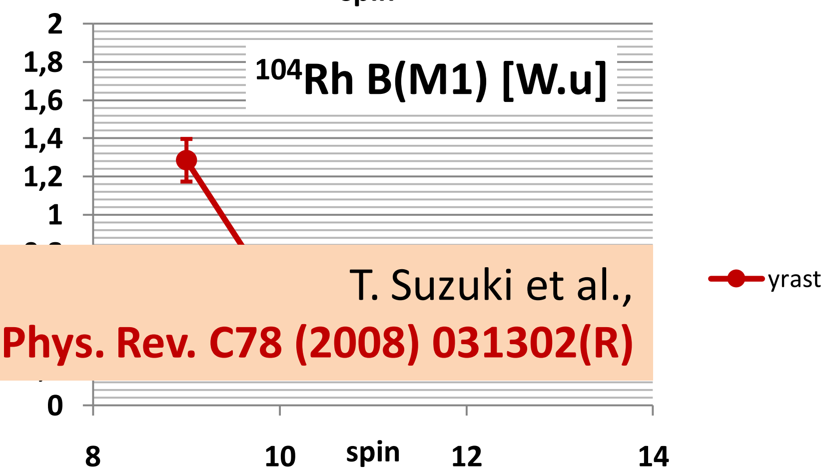
Single-j configuration

~~2qp configuration~~

Triaxiality γ=30

Nonaxial deformation

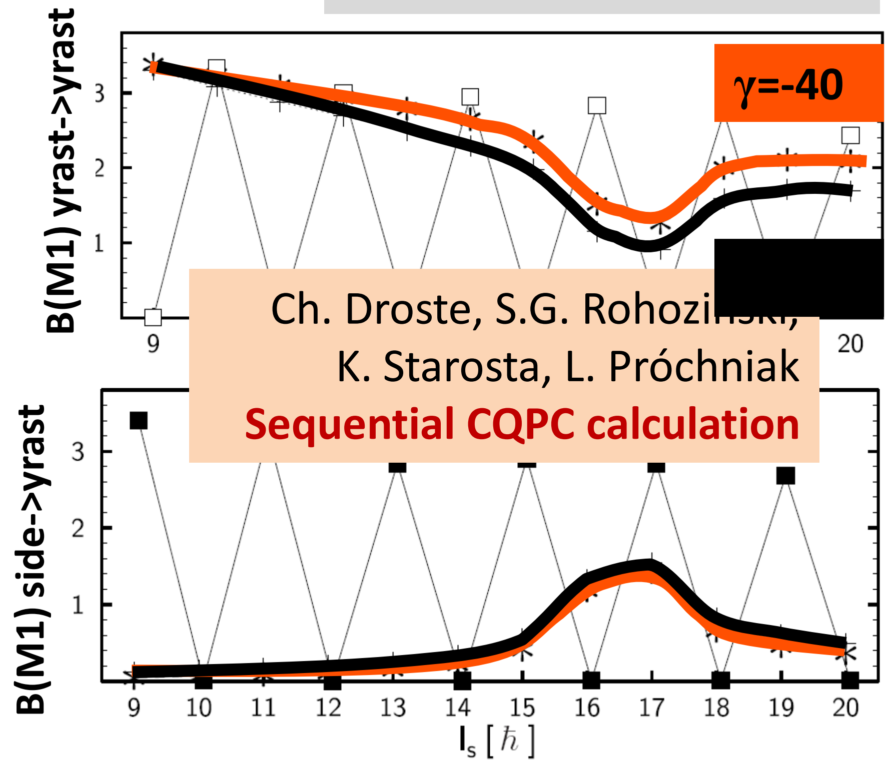
$$\pi h_{11/2} \otimes \nu h_{11/2}$$



T. Suzuki et al.,
Phys. Rev. C78 (2008) 031302(R)

Different-j shell configuration

$$\pi g_{9/2} \otimes \nu h_{11/2}$$



Ch. Droste, S.G. Rohozi[redacted],
K. Starosta, L. Próchniak
Sequential CQPC calculation

G-factors – volume measurement

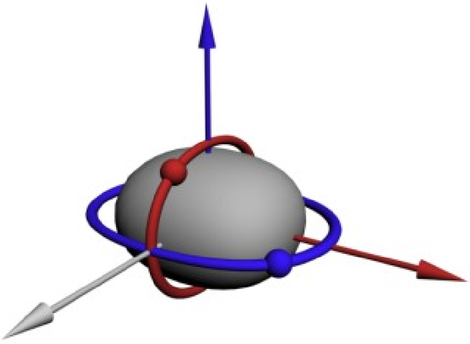
$$g = \frac{1}{2}\left(g_p + g_n + g_R\right)$$

$$+ \frac{1}{J(J+1)}\frac{1}{2} j_p(j_p+1)\left(g_p - g_n - g_R\right)$$

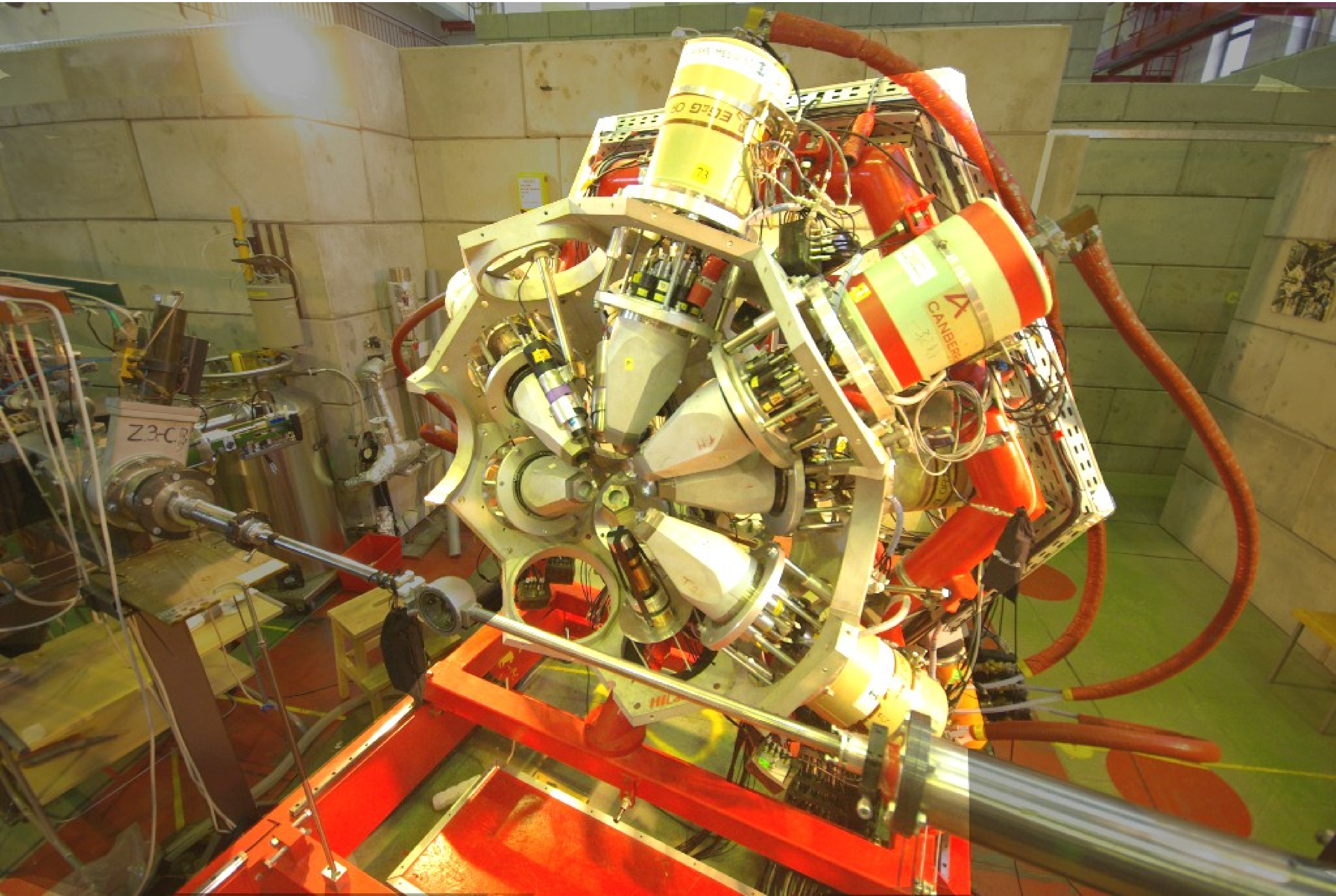
$$+ \frac{1}{J(J+1)}\frac{1}{2} j_n(j_n+1)\left(g_n - g_p - g_R\right)$$

$$+ \frac{1}{J(J+1)}\frac{1}{2} j_R(j_R+1)\left(g_R - g_p - g_n\right)$$

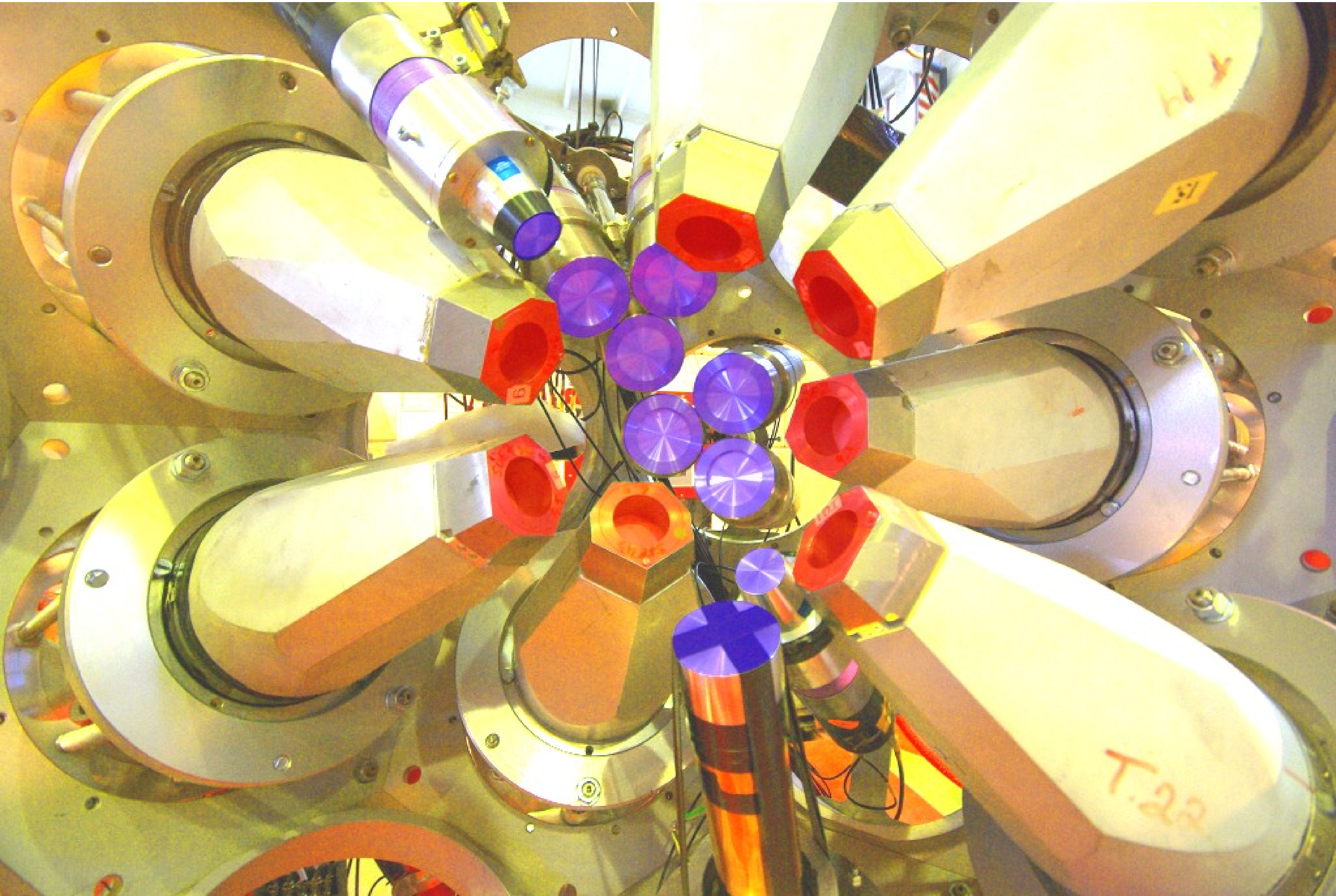
$$- \frac{1}{J(J+1)}\left(g_p \vec{j}_n \cdot \vec{j}_R + g_n \vec{j}_p \cdot \vec{j}_R + g_R \vec{j}_p \cdot \vec{j}_n\right)$$



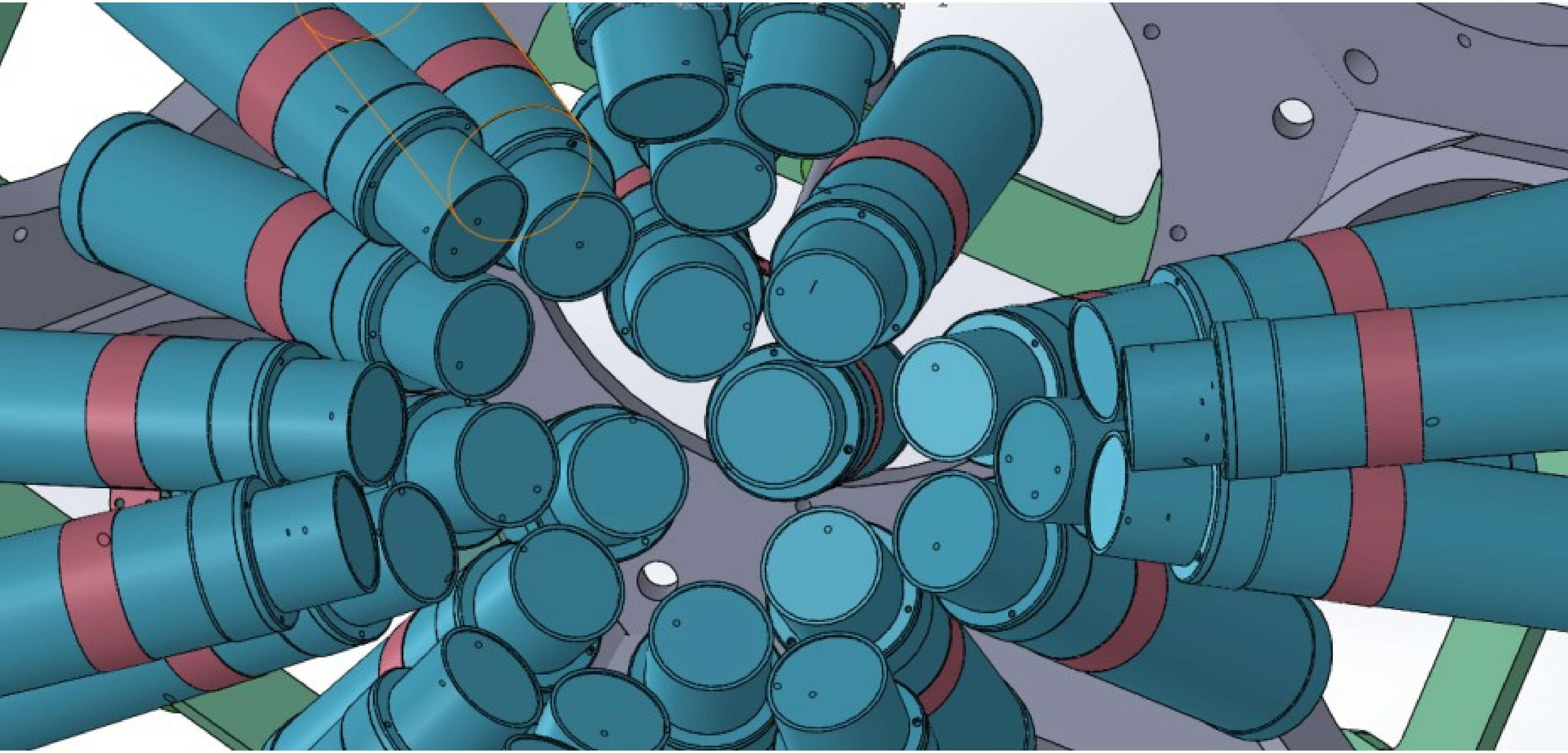
EAGLE EYE – sEquential gammaraYs dEtection



EAGLE EYE – sEquential gammaraYs dEtection



EAGLE EYE – sEquential gammaraYs dEtection
Heavy Ion Laboratory,
University of Warsaw + National Centre for Nucl. Research



Manual summary

$$\left[R_Y T, M\right] = 0$$

Doubling of red. Matrix elemens,

Energies, transition probabilities

Energy-signature staggerings,

- Flat bahaviour – chiral rotation
- Opposite staggering – less chiral character

Chiral bands talk – opposite values,

- Inband mat. element large
- Interband mat. element small

$$\langle I_2, + \| M \| I_1, + \rangle = Re \langle I_2, L \| M \| I_1, L \rangle$$
$$\langle I_2, + \| M \| I_1, - \rangle = Im \langle I_2, L \| M \| I_1, L \rangle$$

EM selection rules – in a subset of chiral nuclei

- single-j configuration
- 2qp states
- Triaxiality $\gamma = 30°$

Volume of 3 ang. Momentum vectors

-g-factor measurements