Check for Chirality in Nuclear Physics

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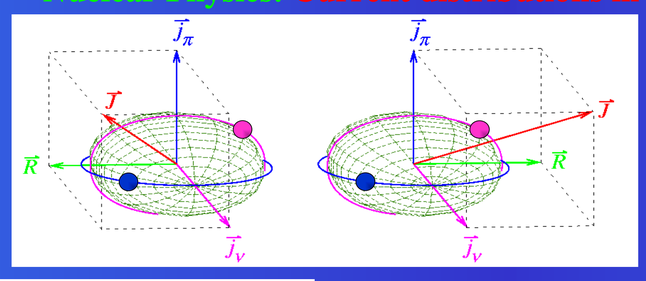
Does Chiral symmetry exists in nuclei ?

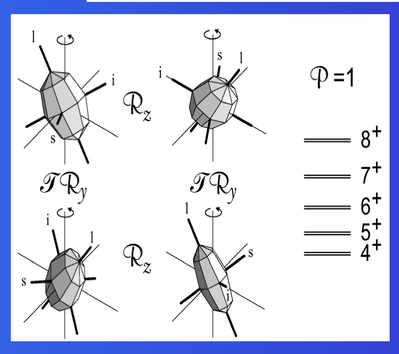
"I call any geometrical figure, or group of points, chiral, and say it has chirality, if its image in a plane mirror, ideally realized, cannot be brought to coincide with itself." - Lord Kelvin 1904

EXAMPLES OF CHIRAL SYSTEMS ARE FOUND IN:

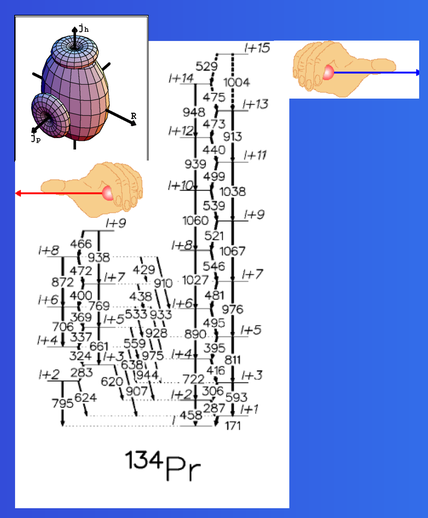
- Chemistry: molecules with opposite handedness react differently in similar environments
- Biology: DNA has right and left-handed "screws"
- Particle Physics

• Nuclear Physics: Current distributions in nuclei

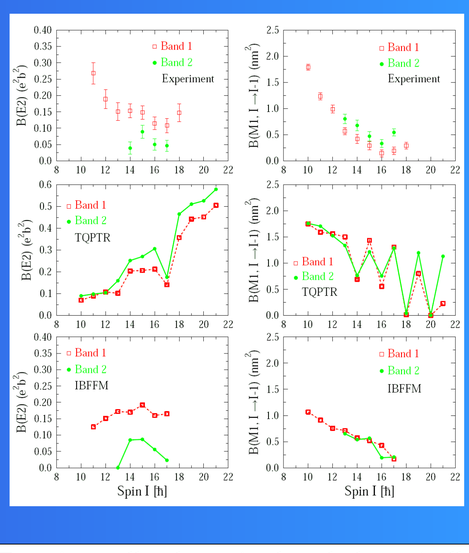




The energies of the excited states for the left-handed and right-handed systems should be identical [1].



Partial level scheme of ^{134}Pr - a candidate for the best chiral example in Nuclear Physics [2].



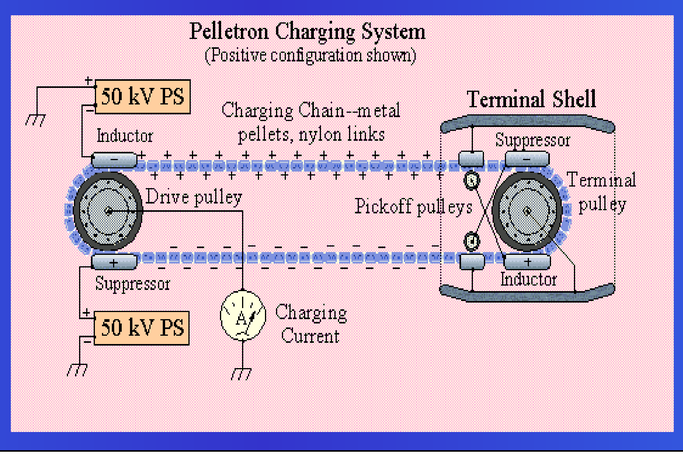
Experimentally determined and theoretically calculated B(E2) and B(M1) transitions strengths in chiral candidate bands of ^{134}Pr. In the upper panels experimental B(E2) and B(M1) values for transitions in Band 1 and Band 2 are presented. In the second row, the results of Two Quasiparticle plus Triaxial Rotor calculations are displayed. In the panels of the bottom the predictions of the IBBFM are shown [3].

EXPERIMENTAL DETAILS:

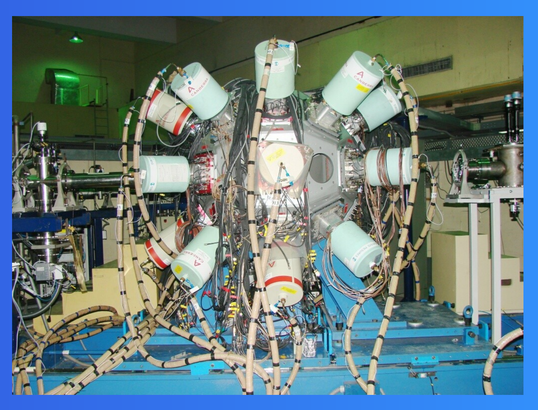
Thick target measurement:

- **A Doppler-shift attenuation experiment was performed at the Inter-University Accelerator Center (IUAC), New Delhi, India using Pelletron accelerator. A beam of ^{11}B was used to produce ^{102}Rh in the 4n reaction exit channel.**
- **Beam Energy: 36.0 MeV of ^{11}B**
- **Target: 0.9 mg/cm ^{94}Zr (enriched to 90 %) evaporated onto 8 mg/cm^2 backing of ^{197}Au.**
- **v/c = 0.9(2) %**

- **The Indian National Gamma Array (INGA), consisted of 15 Clover detectors, was used for the measurement.**
- **4 days measurement.**

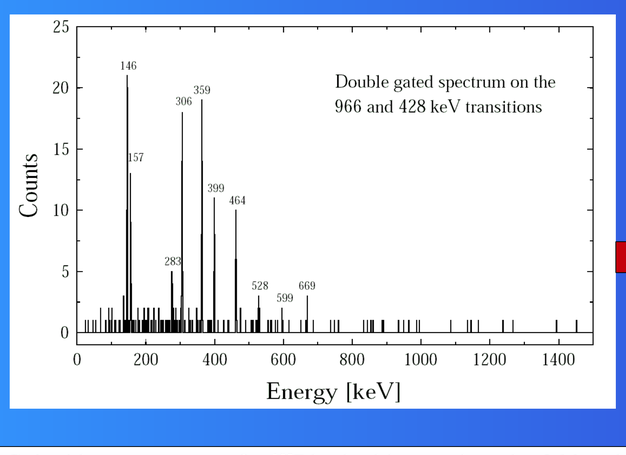


U-Series Pelletron Accelerators can provide ion beams from 500 keV to hundreds of MeV.Terminal Potentials from about 4 MV to >25 MV

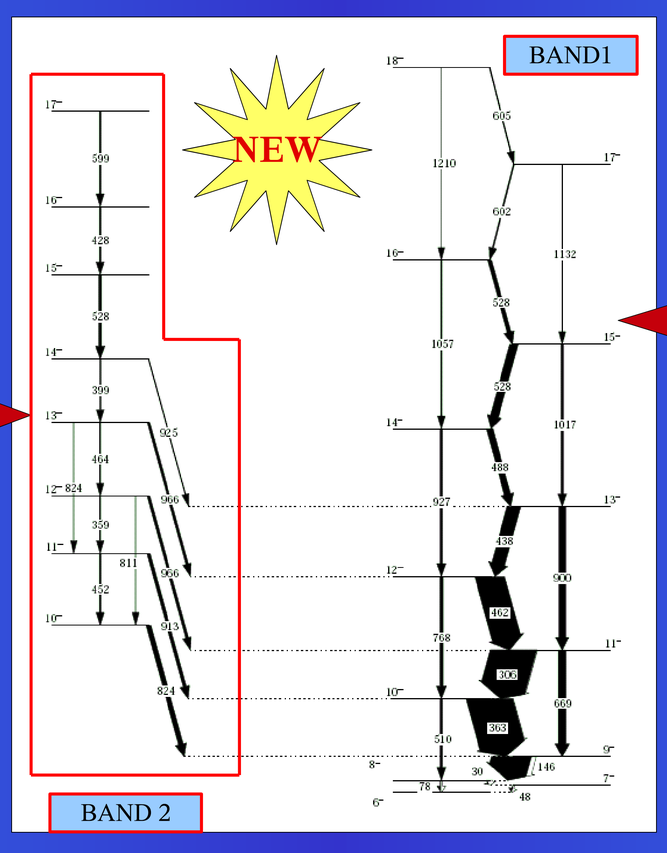


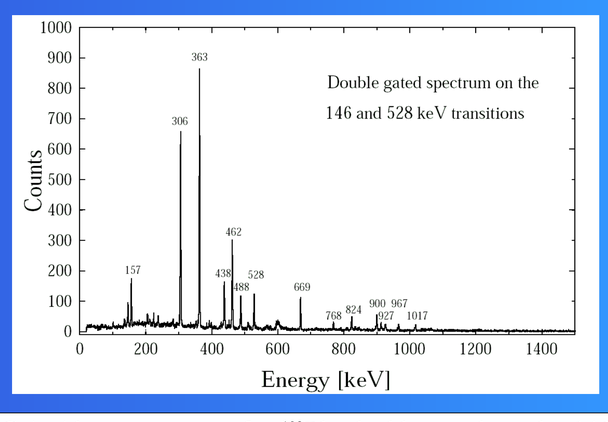
INGA Clover Array

DATA ANALYSES AND RESULTS:



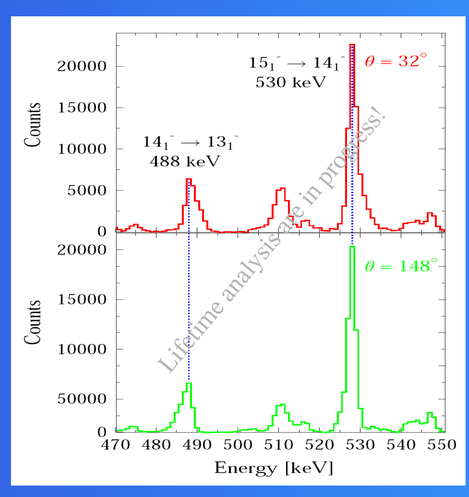
Coincidence spectrum for ^{102}Rh, double gated on the 966 and 428 keV lines. Transitions belonging to the second chiral candidate band are reported for the first time.

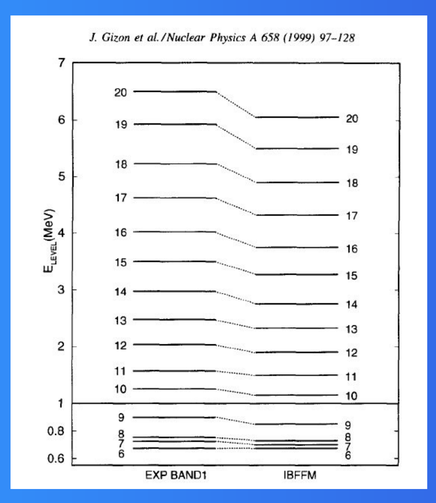




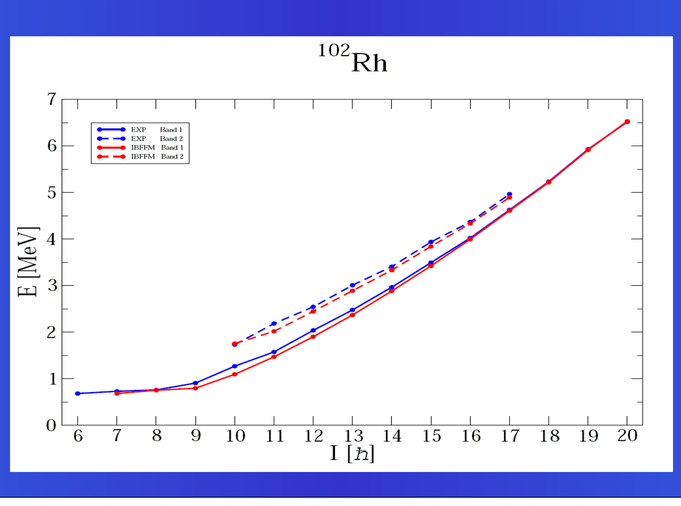
Coincidence spectrum for ^{102}Rh, double gated on the 146 and 528 keV lines.Transitions belonging to the first chiral candidate band are indicated with the corresponding energies.

Partial level scheme of ^{102}Rh. Two negative-parity bands, candidates for chiral partner bands, are indicated as Band 1 and Band 2. The results for the Band 2 are reported for the first time.





IBFFM energy spectrum of the $\pi g_{9/2}\ \nu h_{11/2}$ configuration in ^{102}Rh compared to the experimental Band 1 [5]. Because of the concentration of the lowest states, the bottom of the band is shown with a different scale. The agreement is remarkably good.



Experimentally determined and theoretically calculated energies of excited states of the sister chiral bands in ^{102}Rh. The results of the Interacting Boson Fermion Fermion model are in a very good agreement with the experimental ones [4].

Gated gamma-ray spectra of ^{102}Rh. In the upper panel the shifted and unshifted components of the $(14_1^-) \rightarrow (13_1^-)$ and $(15_1^-) \rightarrow (14_1^-)$ transitions are presented as measured by all detectors positioned at the forward angle of 32.0° with respect to the beam axis. In the bottom panel, the same transitions are presented but at the backward angle of 148°. The data clearly illustrate consistent Doppler-shifts for forward and backward detector rings.

CONCLUSIONS:

- **A thick target measurement was performed at the IUAC, New Delhi, with the INGA spectrometer and US Pelletron.**
- **The level-scheme of the chiral candidate nucleus ^{102}Rh was investigated using a beam of ^{11}B and target of ^{94}Zr onto a gold foil.**
- **For the first time a negative-parity band (Band 2) - candidate for a chiral partner band of the already known negative-parity band (Band 1) - has been established.**
- **The experimentally determined excitation energies are in a very good agreement with the IBFFM calculations for both bands.**
- **A conclusive answer for the chiral nature of the both negative-parity partner bands in ^{102}Rh could be given from the lifetime analyses. Presently they are in progress.**

We thank the accelerator crew of IUAC for excellent support.

REFERENCES:
[1] V. I. Dimitrov et al., Phys. Rev. Lett. 84 (2000) 5732.
[2] K. Starosta et. al., Nucl. A 682 (2001) 375c.
[3] D. Tonev, et al Phys. Rev. Lett 96, 052501 (2006).
[4] S. Brant, private communication.
[5] J. Gizon et al., Nucl. Phys. A 658 (1999) 97.