Pseudospin-chiral quartet bands in ^{131}Ba

Song Guo

Institute of Modern Physics, Chinese Academy of Sciences,

Lanzhou, China

Chirality and Wobbling in Atomic Nuclei, Huizhou, China, 10-14 July, 2023

中国科学院近代物理研究所
Institute of Modern Physics, Chinese Academy of Sciences

On the 25 Anniversity of Chirality (1997-2022)

ELSEVIER

Nuclear Physics A 617 (1997) 131–147

NUCLEAR PHYSICS A

Tilted rotation of triaxial nuclei

S. Frauendorf, Jie Meng [1]

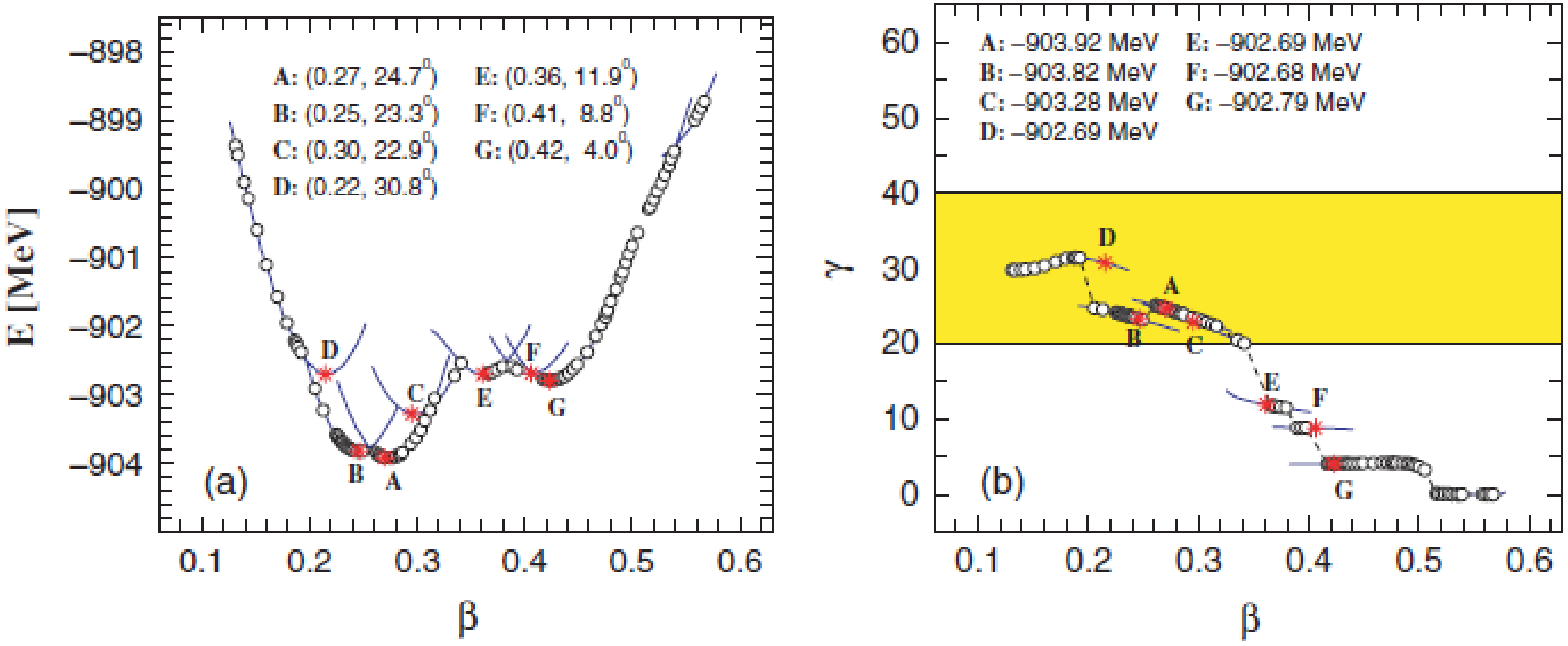
Institut für Kern- und Hadronenphysik, Forschungszentrum Rossendorf e.V., PF 510119, 01314 Dresden, Germany

Received 14 November 1996

We have encountered a new kind of intrinsic symmetry breaking, which is not found among the symmetry types discussed by Bohr and Mottelson in Ref. [11], p. 19. Neither also it correspond to the case without any symmetry, since parity is still a good quantum number. We suggest the name "chiral doubling" for the appearance of the two identical bands in analogy to the "parity doubling" in the case of reflection asymmetric shapes [11]. In the latter case the two bands have opposite parity, though.

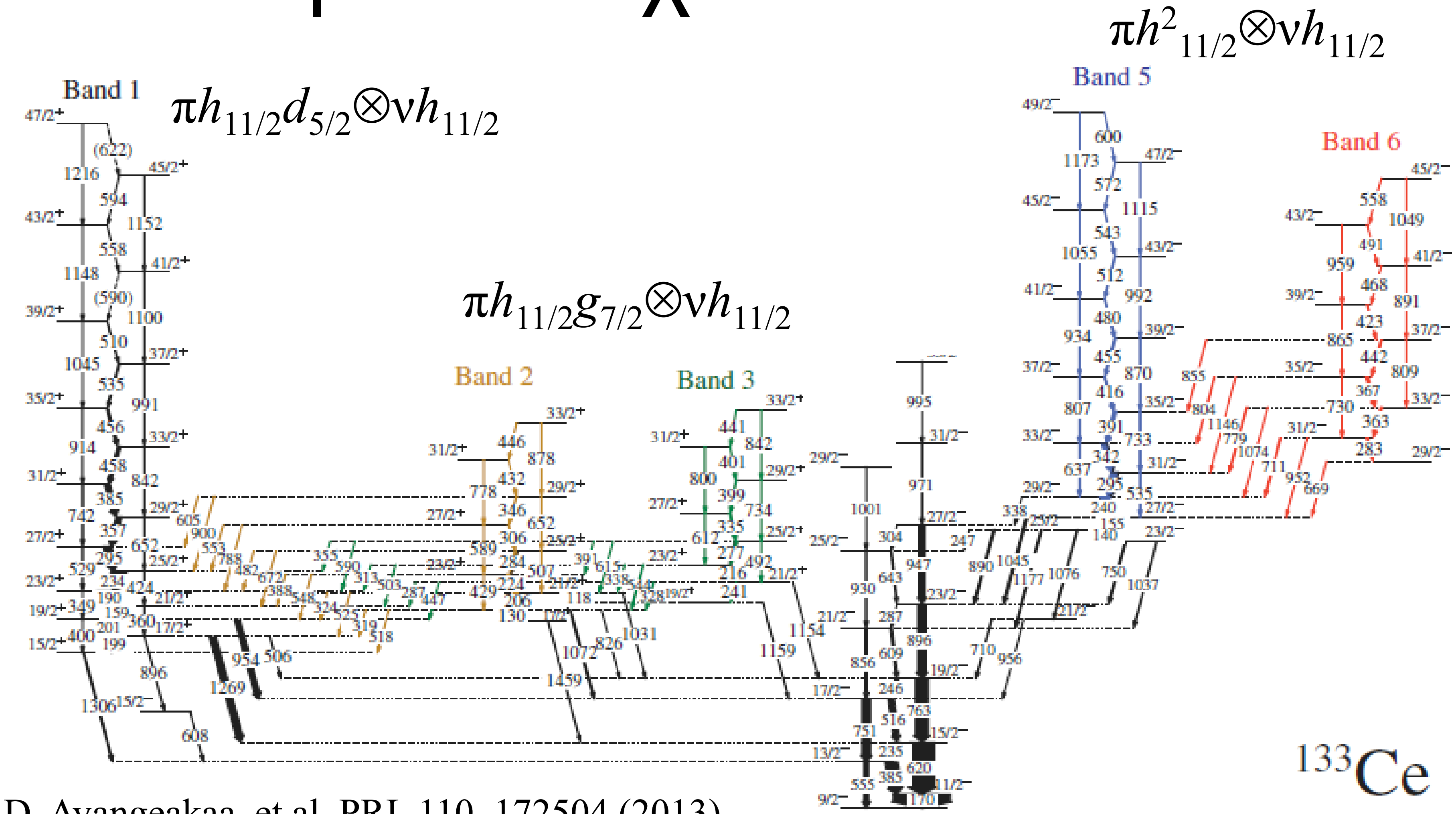
MχD

Multiple chiral doublet bands in one nuclei



J. Meng, J. Peng, S. Q. Zhang and S. -G. Zhou, PRC 73, 037303 (2006)

First example of MχD in ^{133}Ce

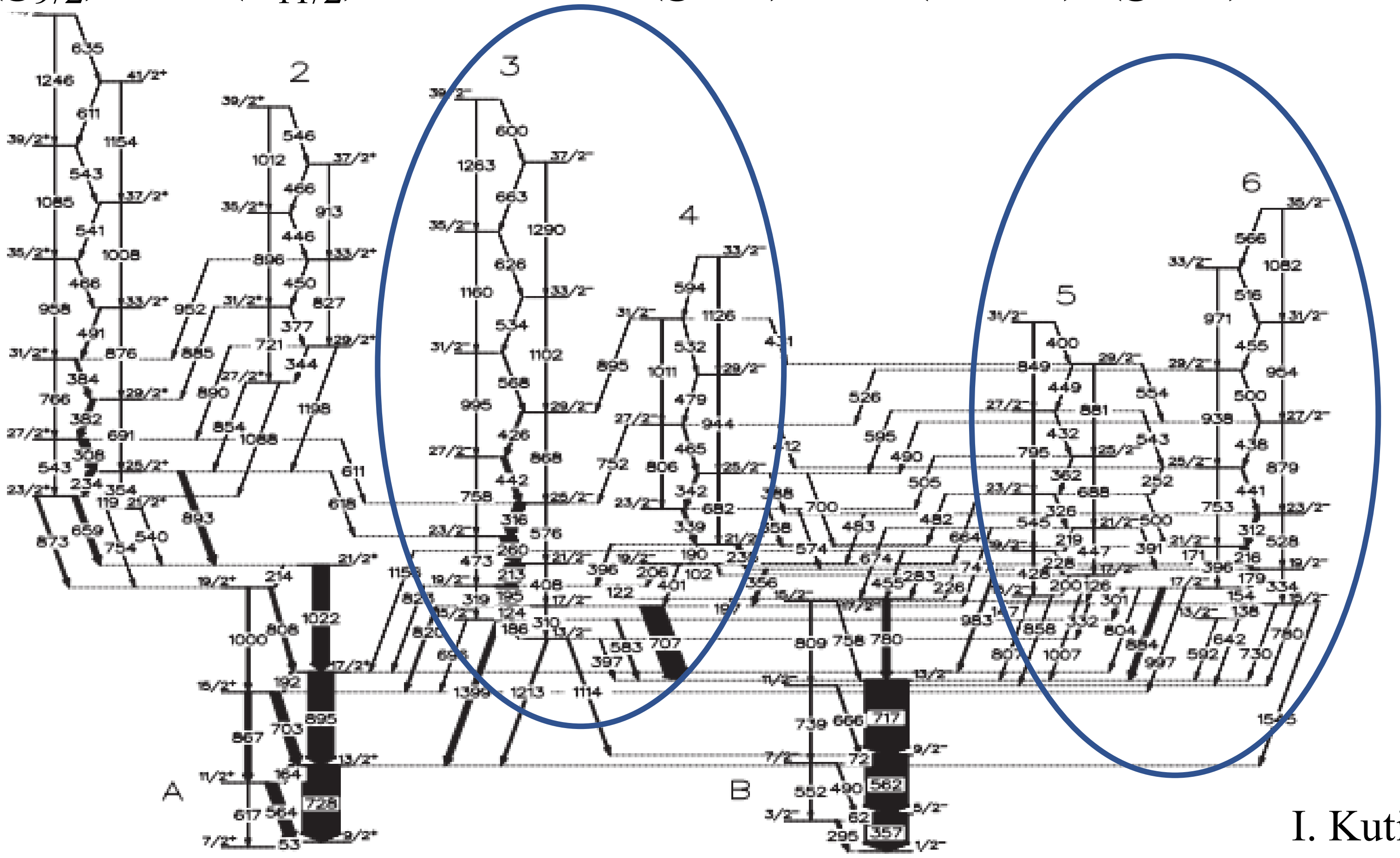


A. D. Ayangeakaa, et al, PRL 110, 172504 (2013)

MχD of identical configuration in ^{103}Rh

$\pi(g_{9/2})^{-1} \otimes \nu\,(h_{11/2})^2$

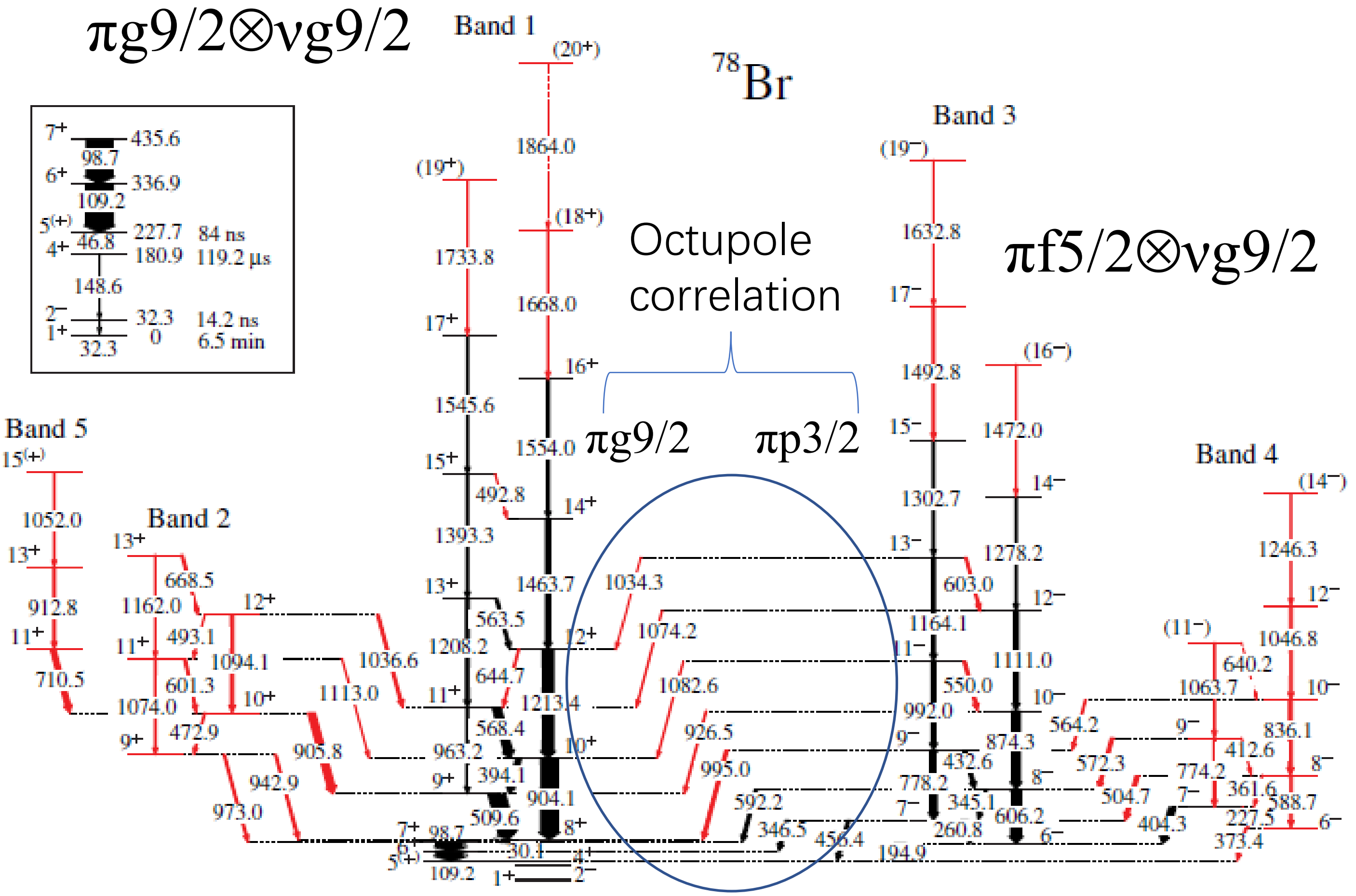
$\pi(g9/2)^{-1} \otimes \nu\,(h11/2)^1(g7/2)^1$

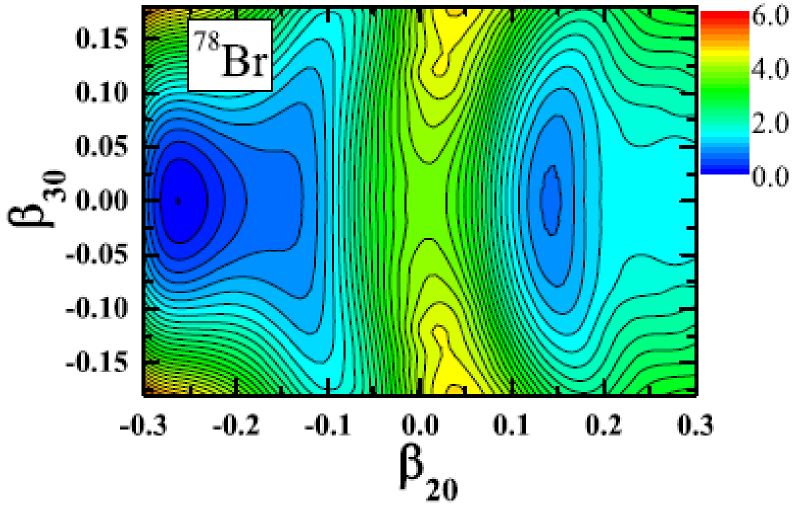


Two pair of chiral doublet bands with near-degeneracy energy

I. Kuti, et al, PRL113, 032501 (2014)

MχD linked by octupole correlation in ^{78}Br

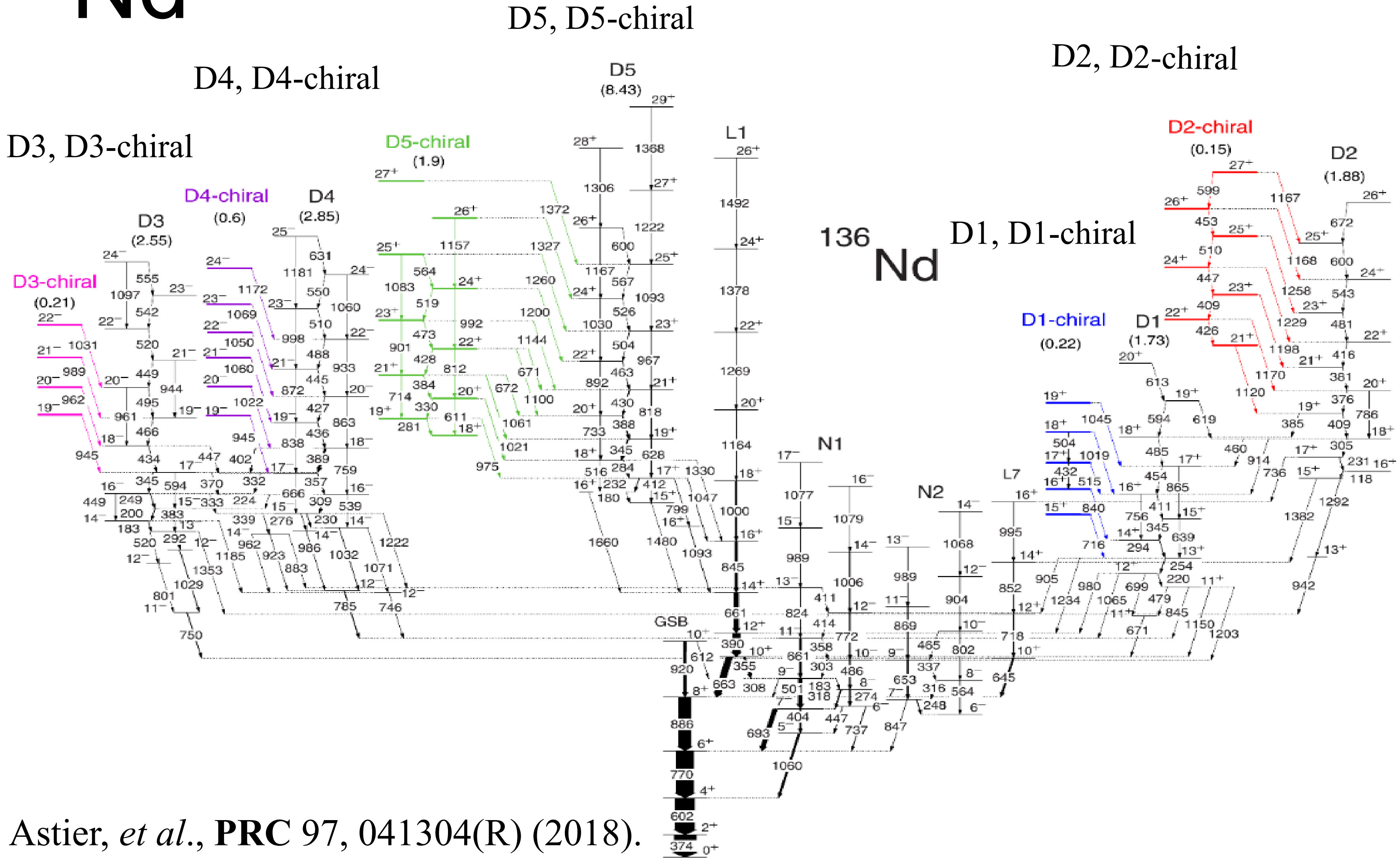




Triggered the interests on chirality-parity quartet bands

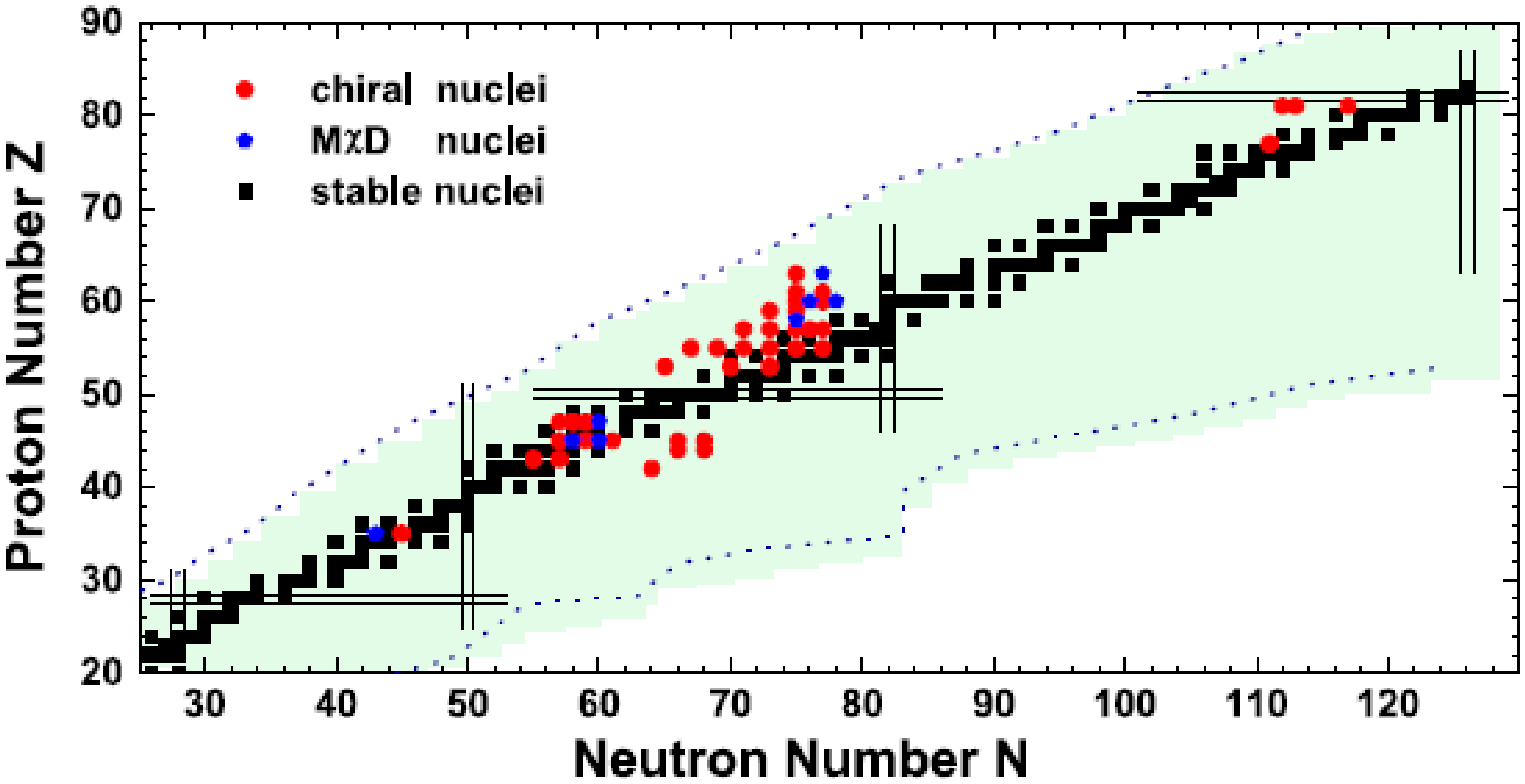
C. Liu, et al, PRL 116, 112501 (2016)

MχD in ^{136}Nd



C. M. Petrache, **B. F. Lv** , A. Astier, *et al.*, **PRC** 97, 041304(R) (2018).

Territory of chirality

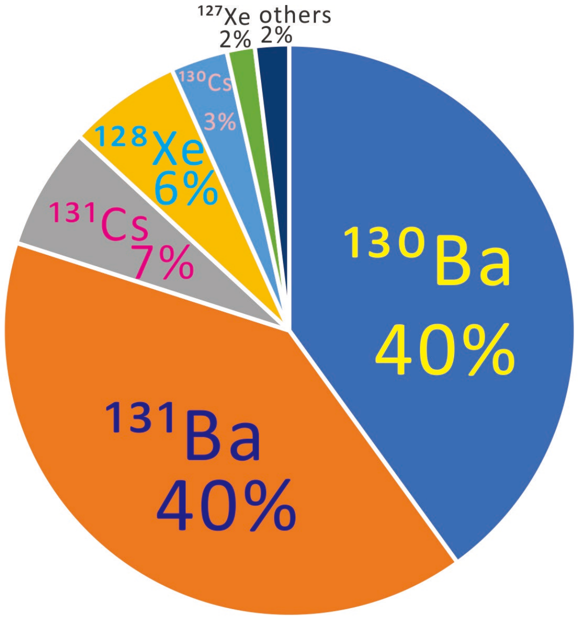


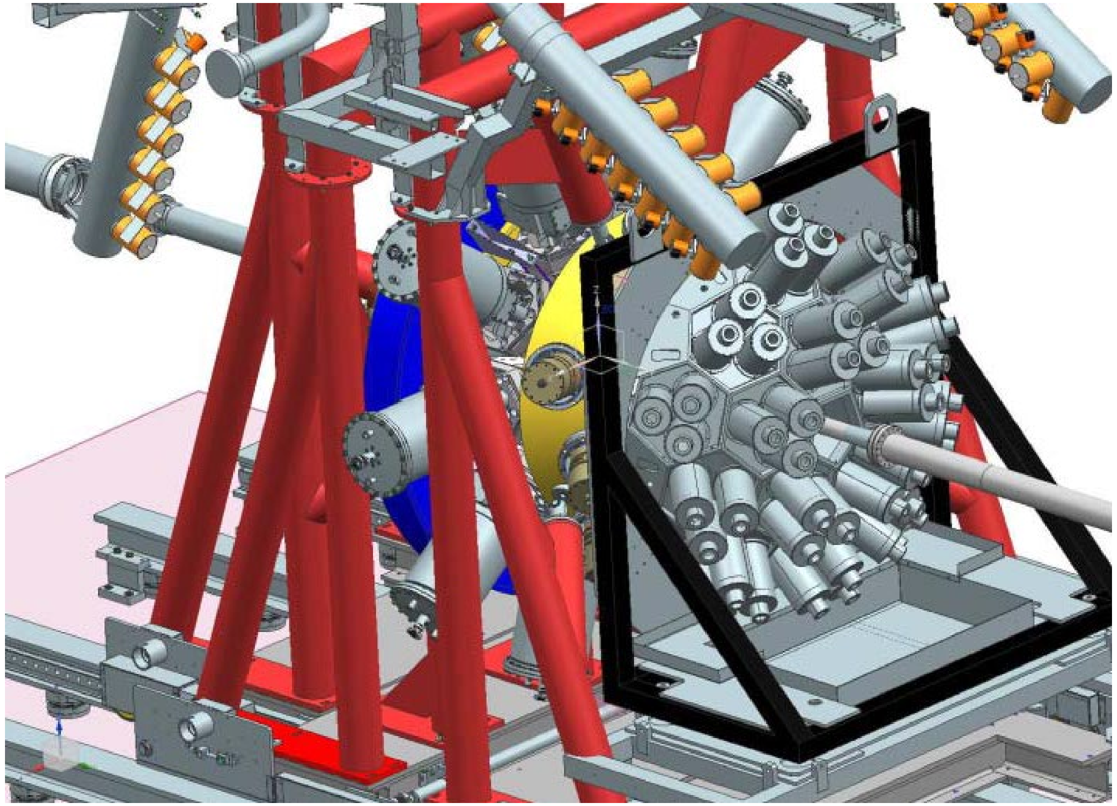
B. W. Xiong and Y. Y. Wang, Atomic Data and Nuclei Data Tables 125, 193 (2019)

Experiment on ^{130,131}Ba @ Legnaro

Spokesperson: Costel Petrache

- Beam: ^{13}C @ 65 MeV
- Target: ^{122}Sn 2 × 0.5 mg/cm^2
- Total crosssection: 1.1b





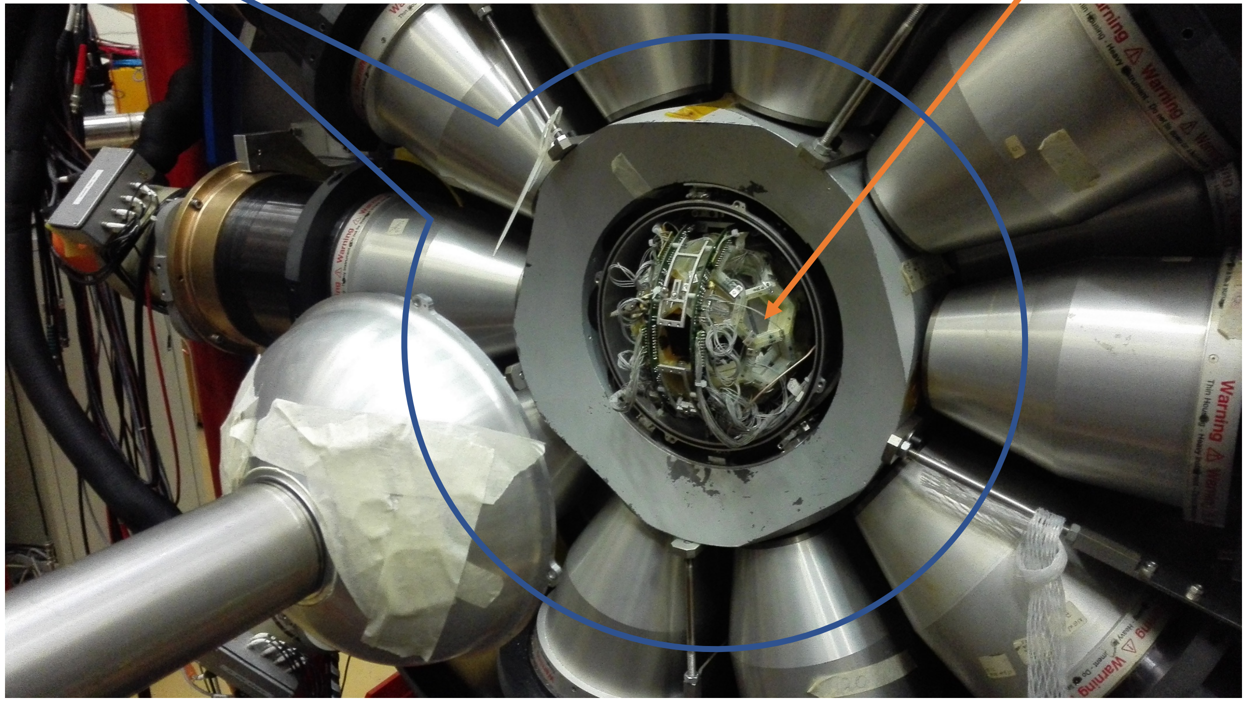
GALILEO

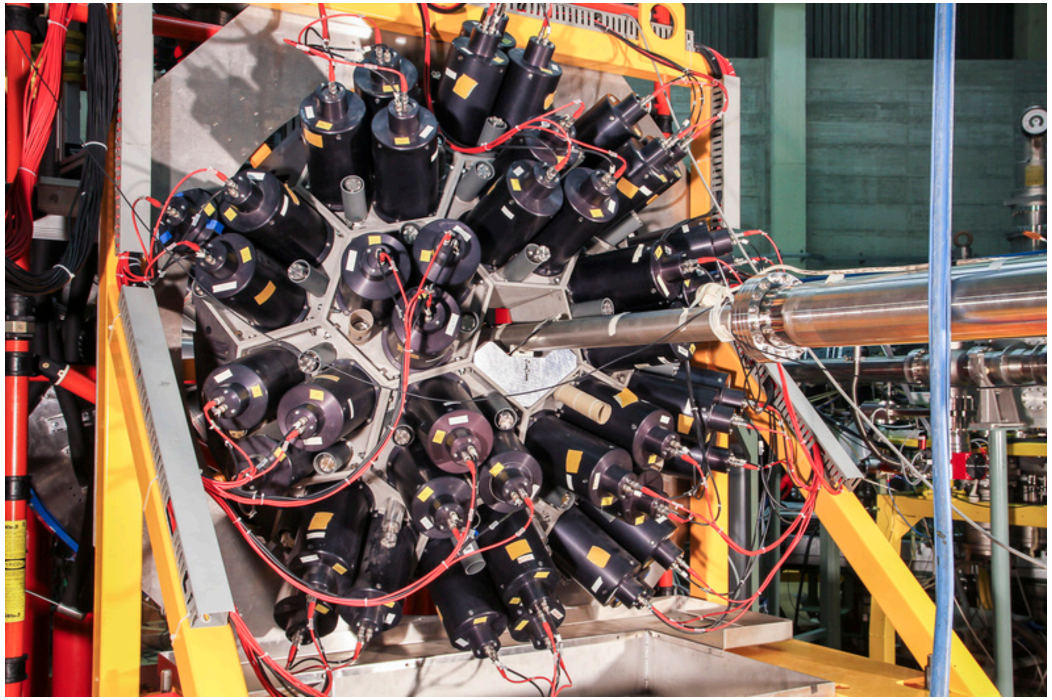
HpGe detectors: → Triple events: 1.2×10^{9}

90°	129 °	119 °	152 °
10	5	5	5

Euclides

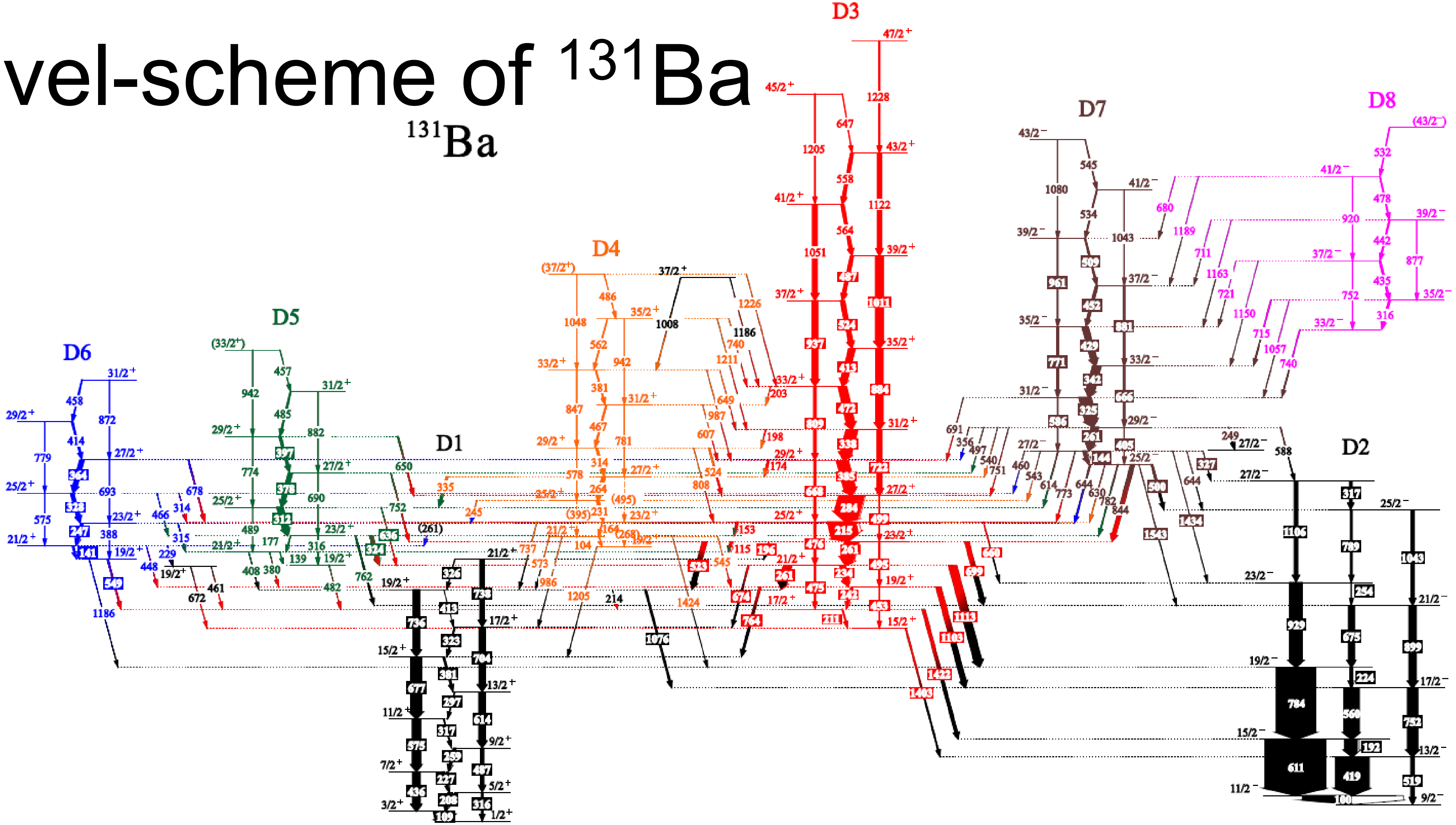
Neutron Wall





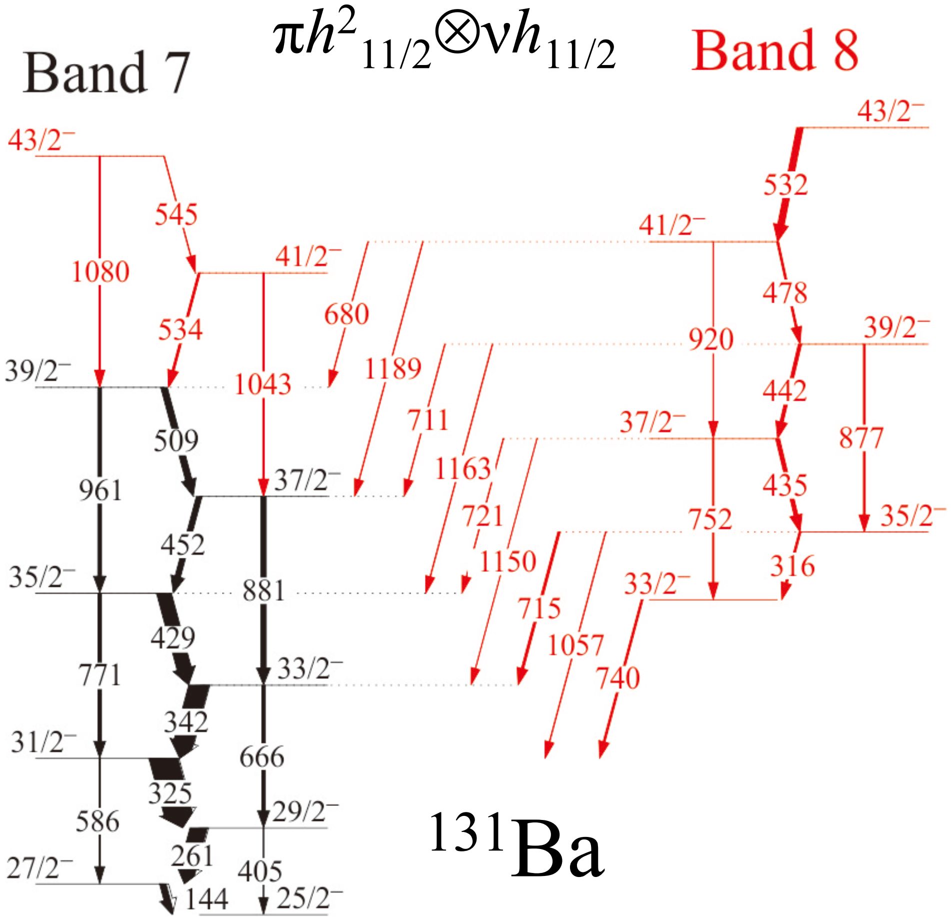
中国科学院近代物理研究所
Institute of Modern Physics, Chinese Academy of Sciences

Level-scheme of ^{131}Ba

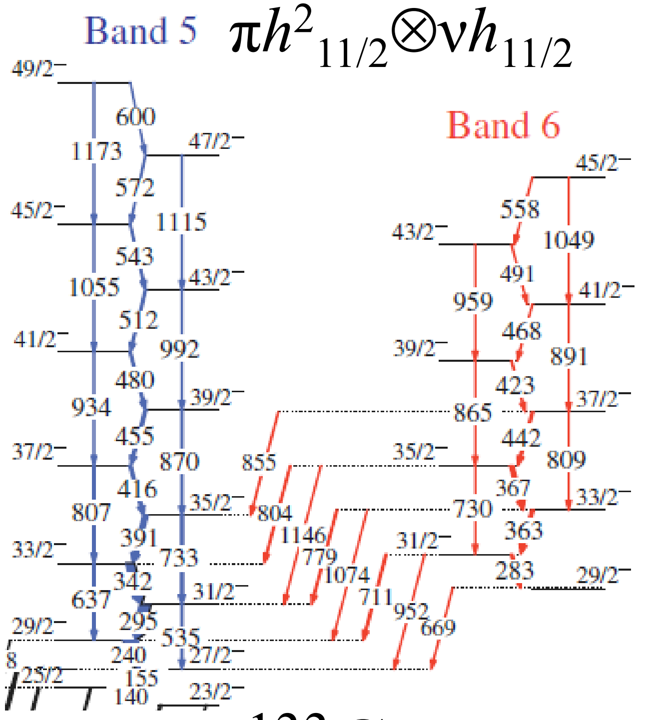


SG, C.M. Petrache, D. Mengoni, et al, PLB 807, 135572 (2020)

Negative parity bands

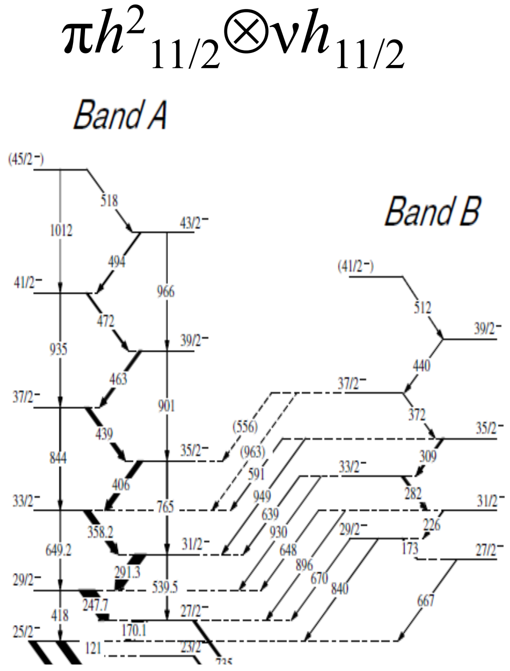


^{131}Ba



^{133}Ce

A. D. Ayangeakaa, et al,
B. PRL 110, 172504 (2013)

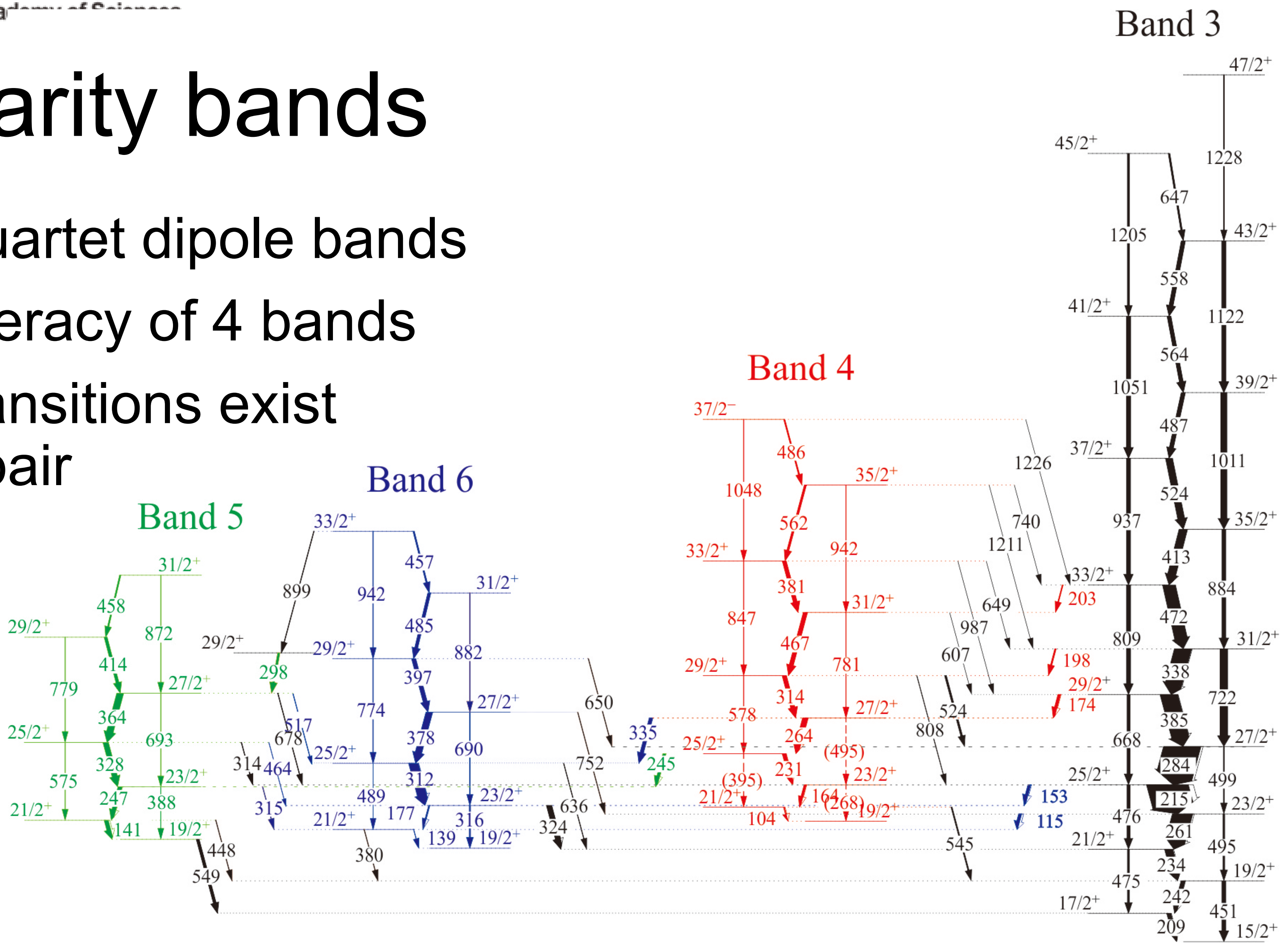


^{135}Nd

S. Zhu, et al, PRL 91, 132501 (2003)

Positive parity bands

- Structure of quartet dipole bands
- Energy degeneracy of 4 bands
- Connecting transitions exist between any pair

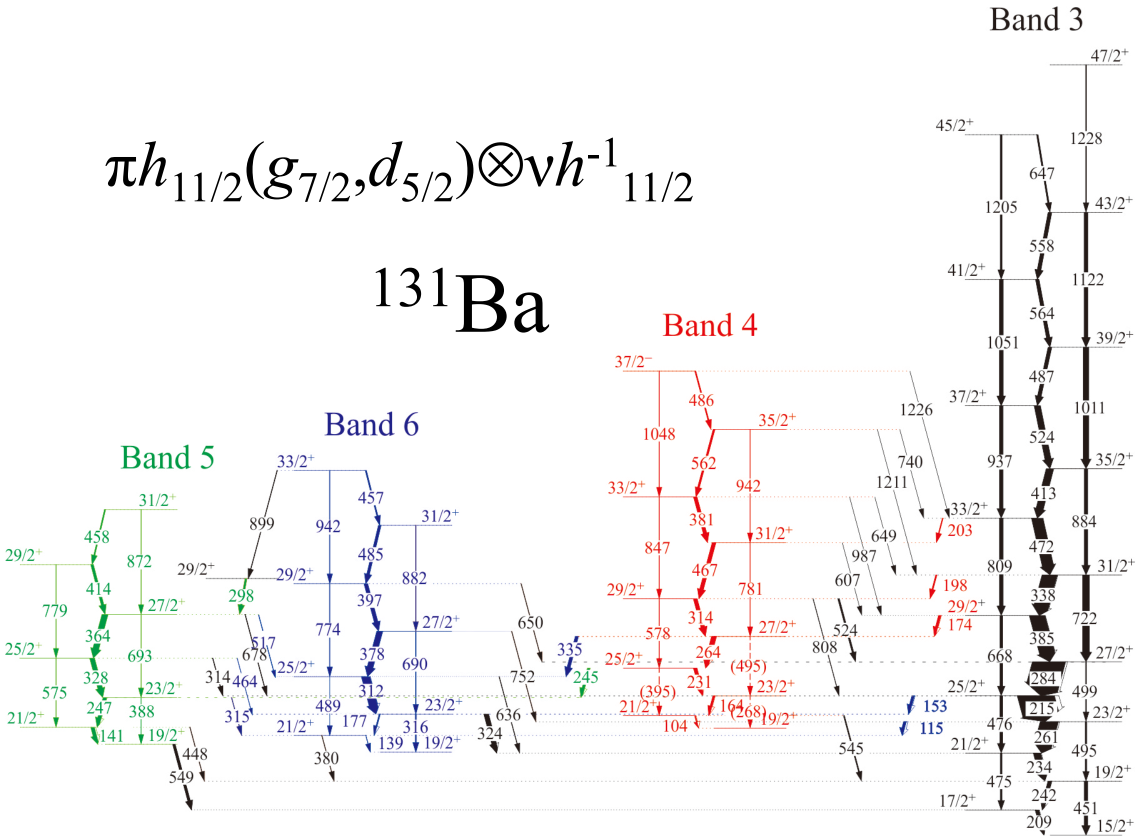


中国科学院近代物理研究所
Institute of Modern Physics, Chinese Academy of Sciences

Structures in isotones

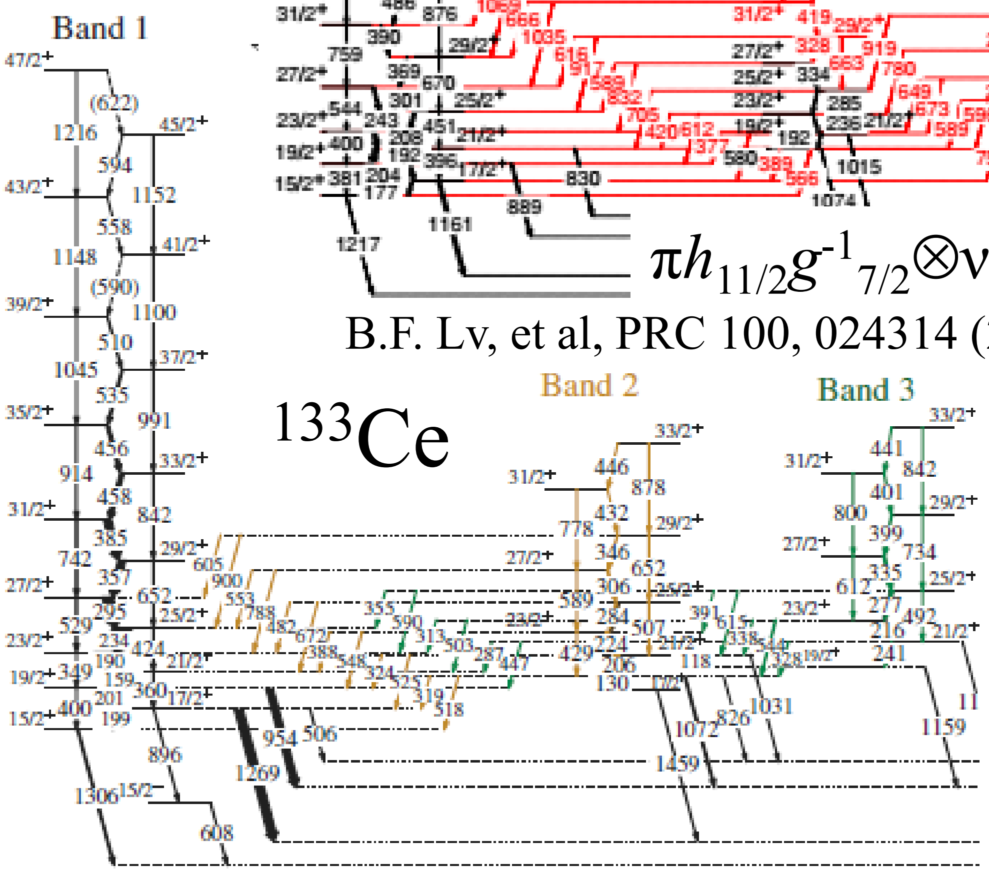
$\pi h_{11/2}(g_{7/2},d_{5/2})\otimes\nu h^{-1}_{11/2}$

^{131}Ba



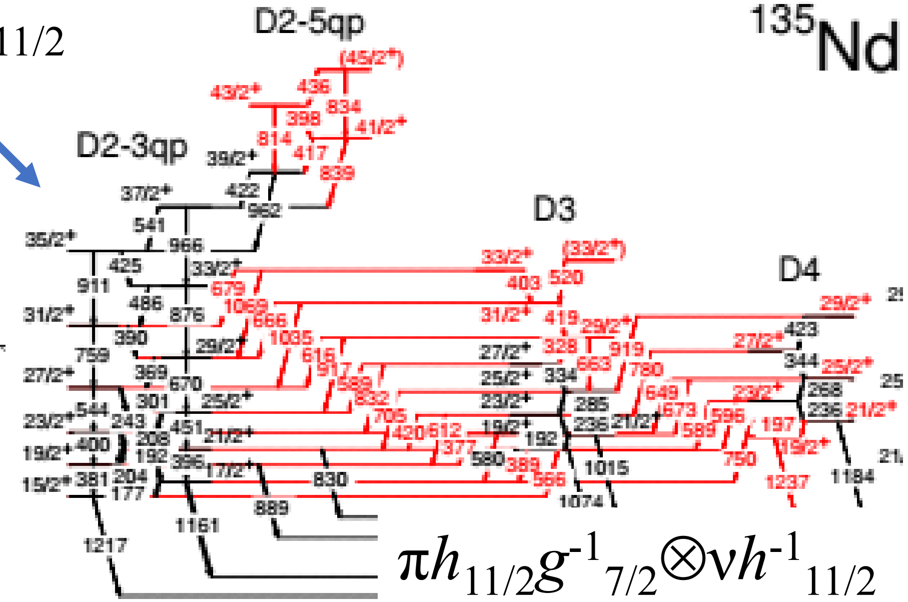
$\pi h_{11/2}d_{5/2}\otimes\nu h^{-1}_{11/2}$

^{133}Ce



A. D. Ayangeakaa, et al, PRL 110, 172504 (2013)

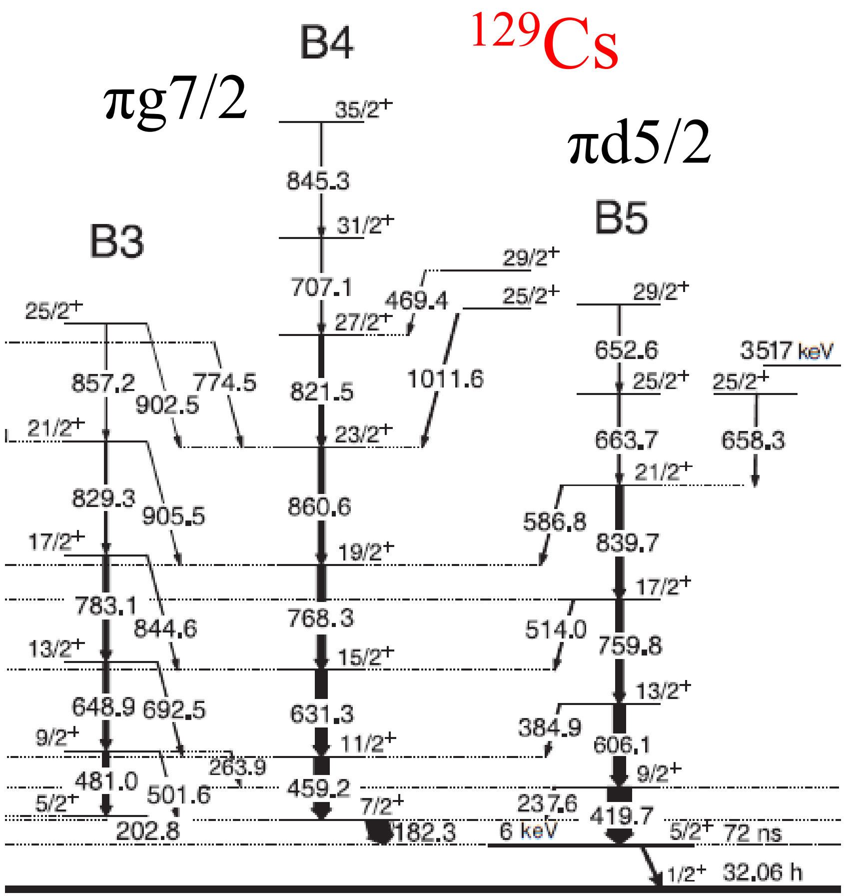
^{135}Nd



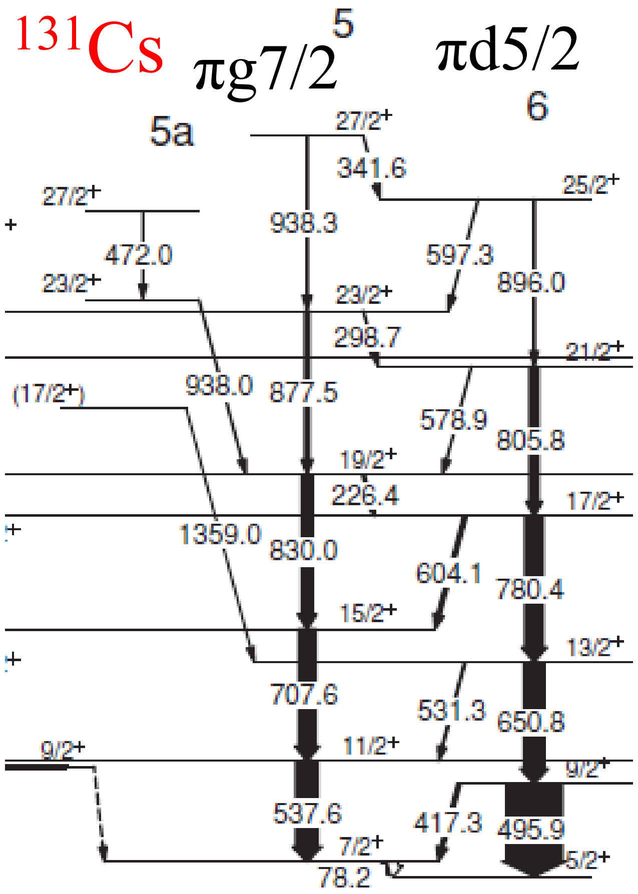
$\pi h_{11/2}g^{-1}_{7/2}\otimes\nu h^{-1}_{11/2}$

B.F. Lv, et al, PRC 100, 024314 (2019)

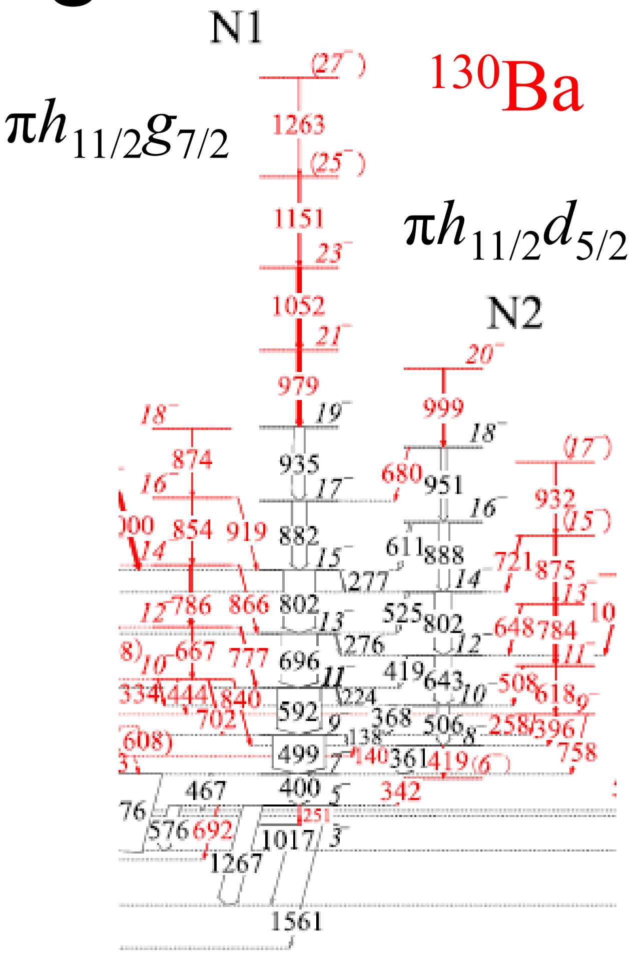
Pseudospin partners in neighboring nuclei



S. Sihotra, et al, PRC **79**, 044317 (2009)

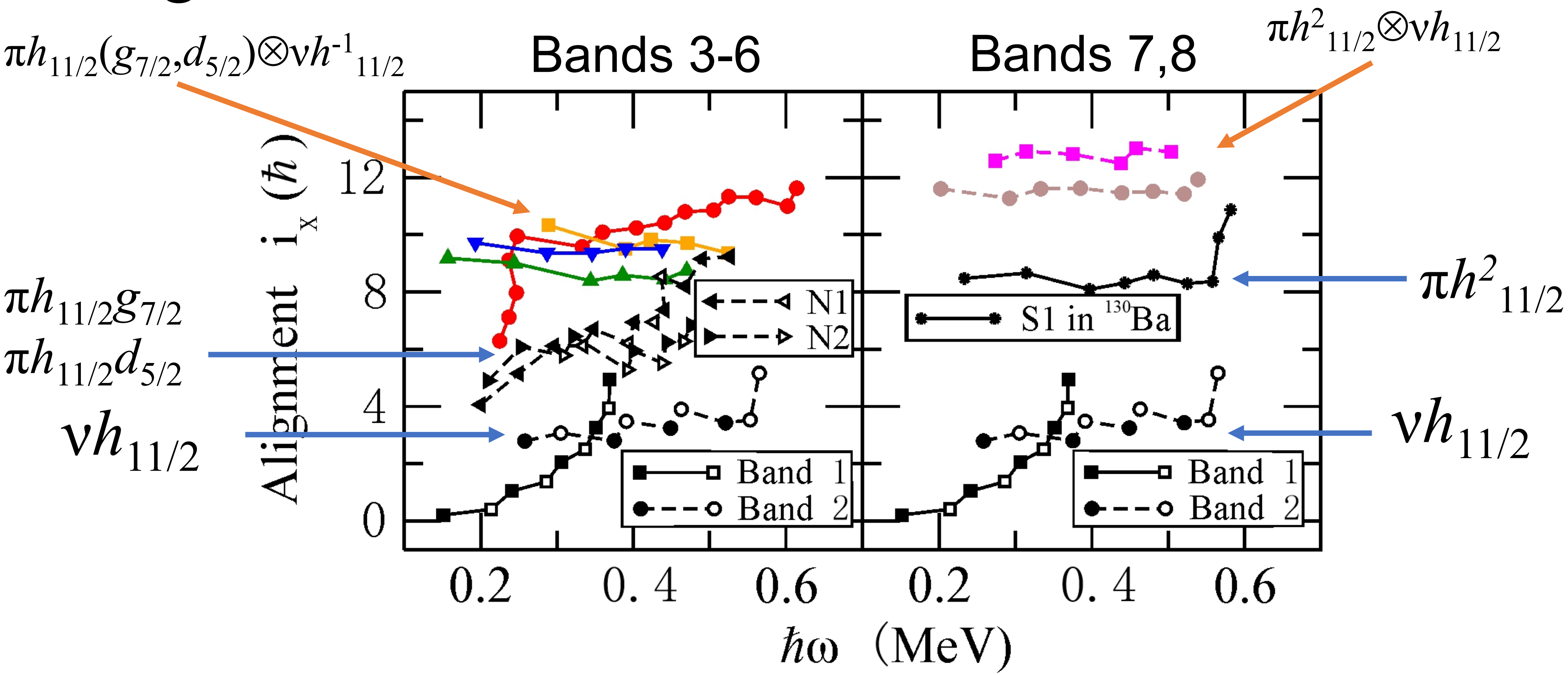


S. Sihotra, et al, PRC **78**, 034313 (2008)



S. Guo, et al, PRC **102**, 044320 (2020)

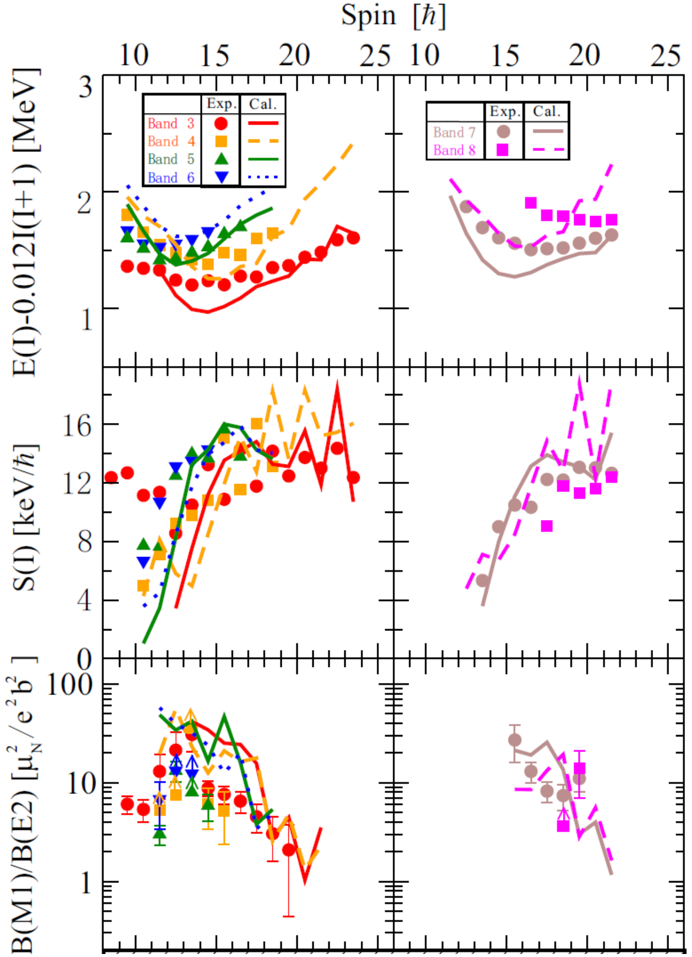
Alignment

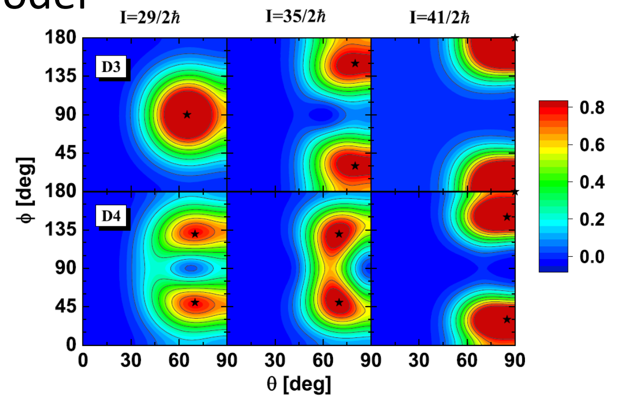

πh11/2(g7/2,d5/2)⊗νh-111/2
Bands 3-6
Bands 7,8
πh211/2⊗νh11/2
πh11/2g7/2
πh11/2d5/2
νh11/2
πh211/2
νh11/2
Alignment ix (ħ)
12
8
4
0
N1
N2
S1 in 130Ba
Band 1
Band 2
Band 1
Band 2
0.2
0.4
0.6
0.2
0.4
0.6
ħω (MeV)

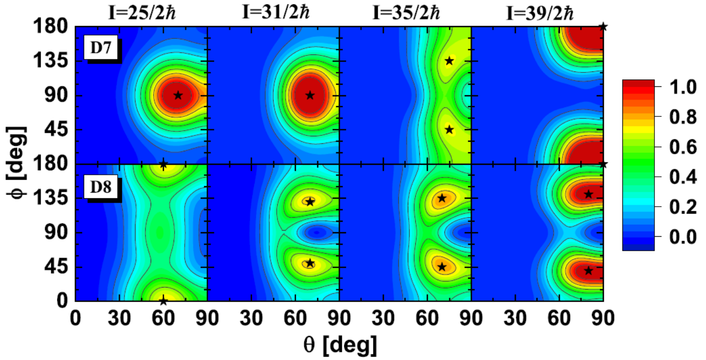
中国科学院近代物理研究所
Institute of Modern Physics, Chinese Academy of Sciences

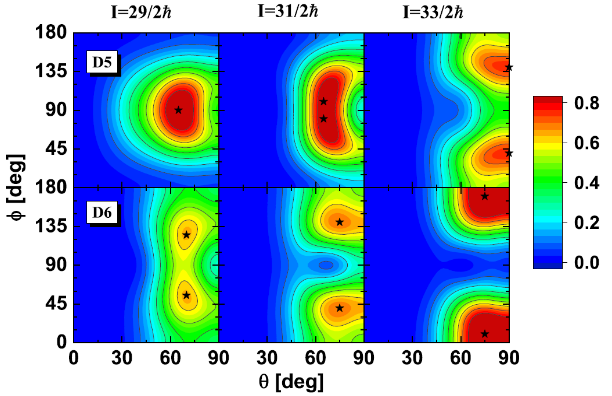
Theoretical support

reflection-asymmetric triaxial particle rotor model









Chiral vibration

Static chirality

Principle axis rotation

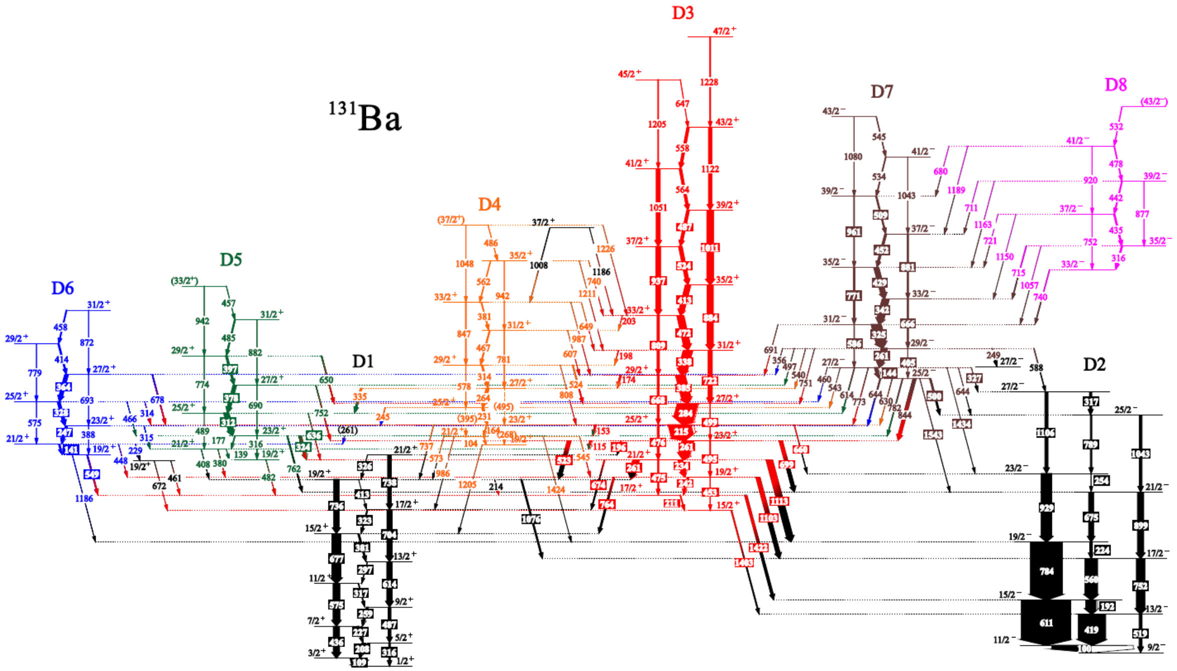
Y. P. Wang, Y. Y. Wang, J. Meng, PRC **102**, 024313 (2020)

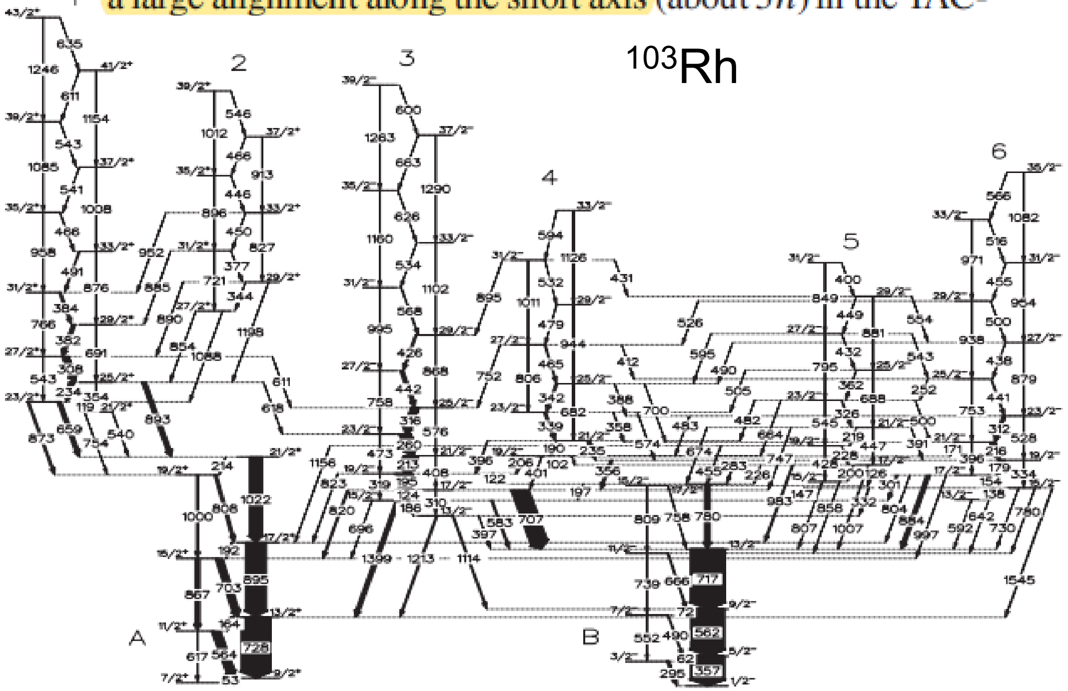
Pseudospin-chirality VS same configuration

^{131}Ba: Z=56 π($h_{11/2}$, $g_{7/2}$, $d_{5/2}$)
^{103}Rh: N=58 ν($h_{11/2}$, $g_{7/2}$, $d_{5/2}$)
Four energy degenerated rotational bands
Plenty of linking transitions

For positive-parity bands, we fixed the high-j orbitals $\pi(1g_{9/2})^{-1} \otimes \nu(1h_{11/2})^2$, while for negative-parity bands we fixed the $\pi(1g_{9/2})^{-1} \otimes \nu(1h_{11/2})^1$. The calculated ener-

tive-parity configuration, a $g_{7/2}$ neutron is found to contribute a large alignment along the short axis (about $3\hbar$) in the TAC-

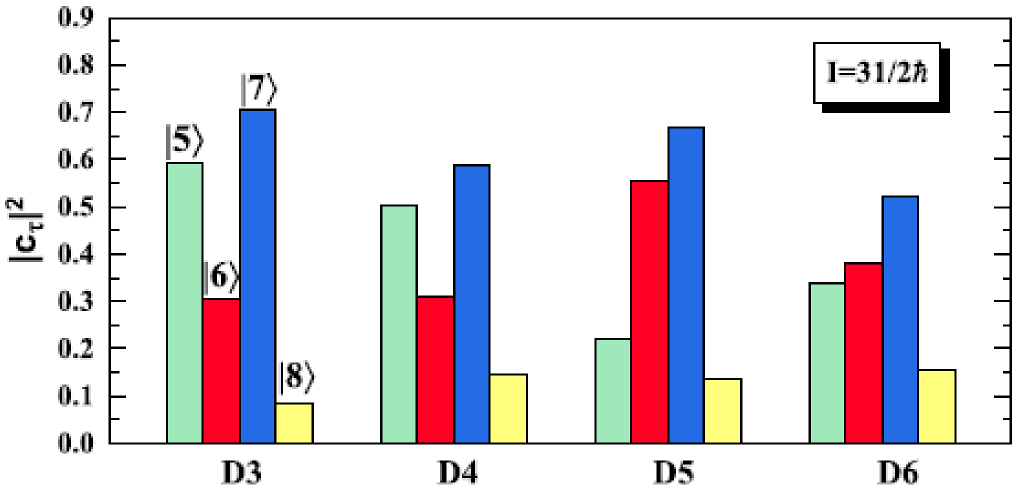


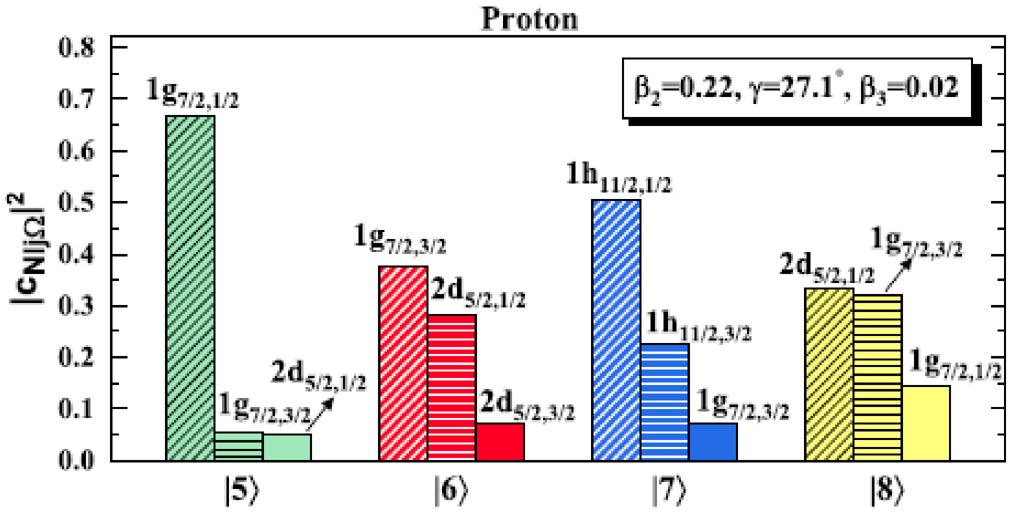


Pseudospin-chiral as preferable interpretation

the intrinsic wave functions is $\pi h_{11/2} g_{7/2} \otimes \nu h_{11/2}$ for bands D3-D4, in comparison with $\pi h_{11/2}(g_{7/2}, d_{5/2}) \otimes \nu h_{11/2}$ for bands D5-D6.

Thus the positive-parity MχD candidates involve the pseudospin partners $(g_{7/2}, d_{5/2})$ and are suggested to be pseudospin-chiral quartet bands.

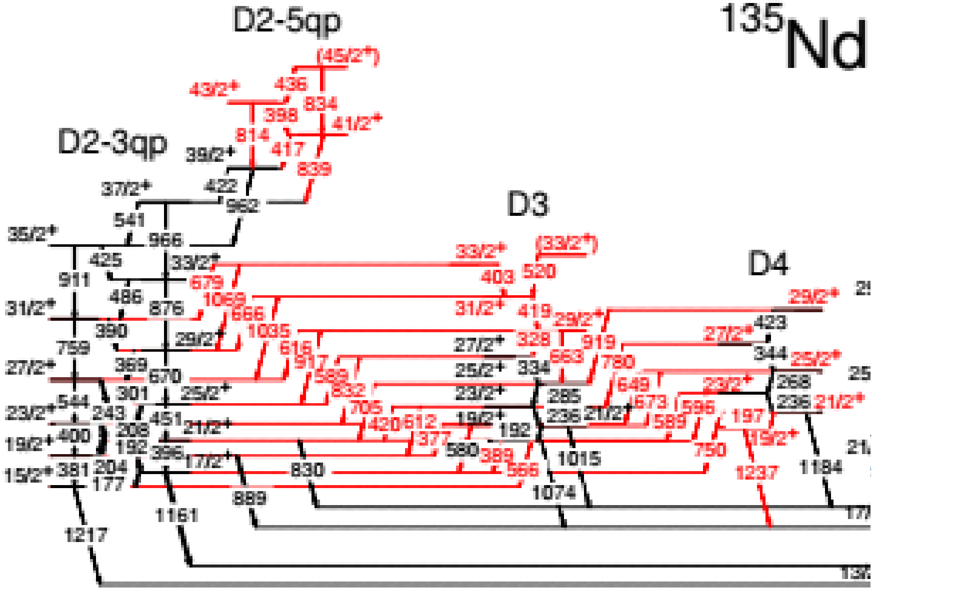




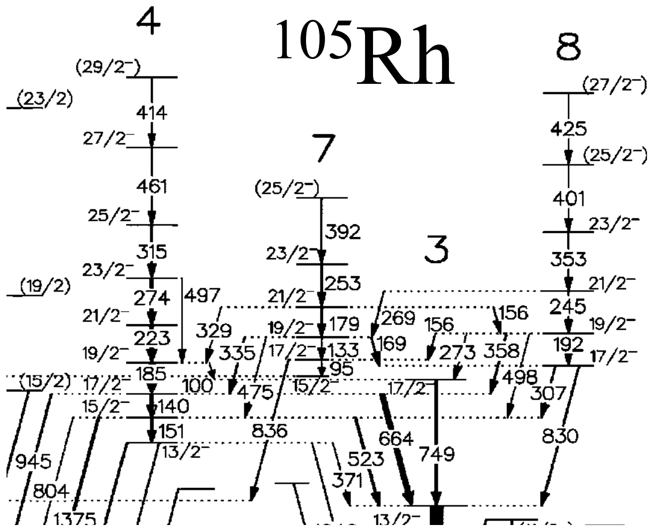
Y. P. Wang, Y. Y. Wang, J. Meng, PRC **102**, 024313 (2020)

Triple bands

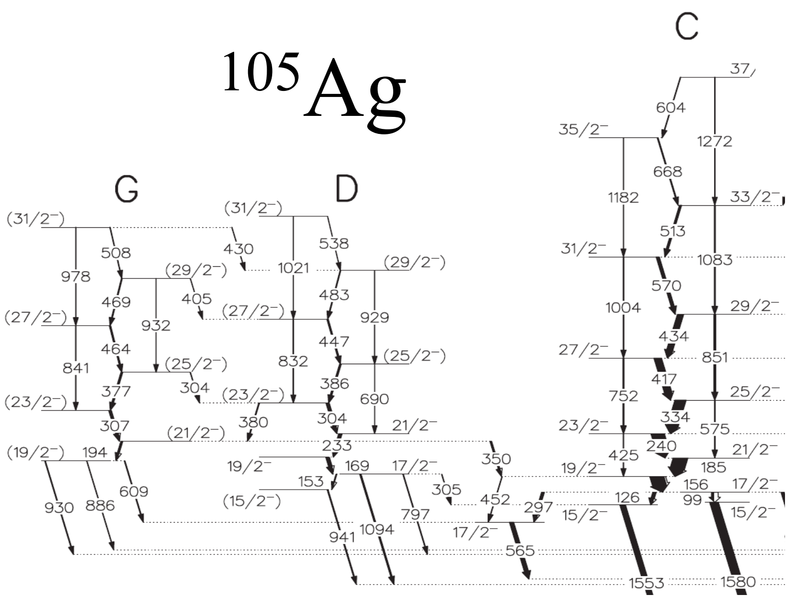
One yrast band
Two yrare bands as chiral doublet



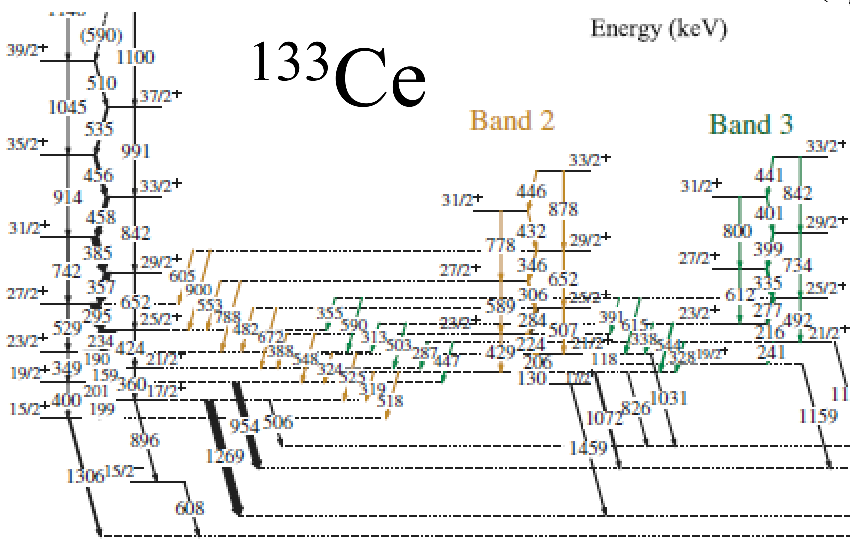
B.F. Lv, et al, PRC 100, 024314 (2019)



J. A. Alcántara-Núñez, *et al.*, Phys. Rev. C 69, 024317 (2004)



J. Timár, *et al.*, Phys. Rev. C 76, 024307 (2007)
H. Jia , *et al.*, J. Phys. G 46, 035102(2019)

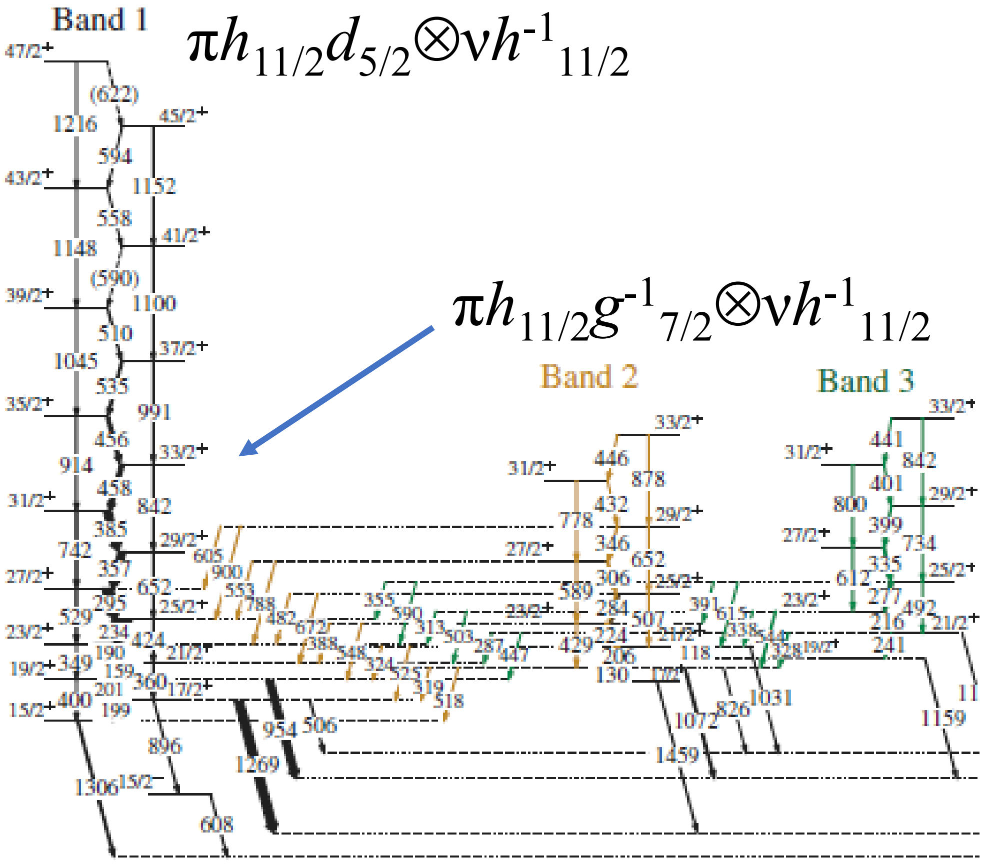


A. D. Ayangeakaa, et al, PRL 110, 172504 (2013)

Comparing ^{131}Ba and ^{133}Ce

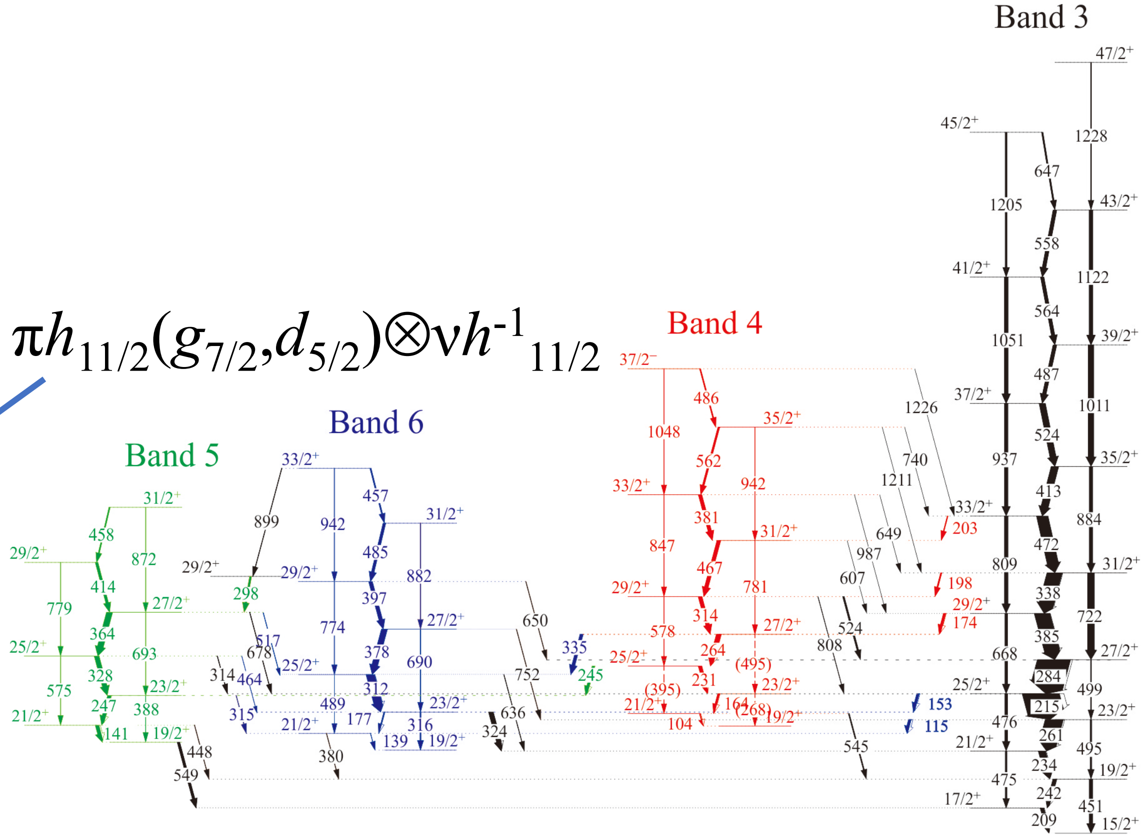
$\pi h_{11/2} d_{5/2} \otimes \nu h^{-1}_{11/2}$

$\pi h_{11/2} g^{-1}_{7/2} \otimes \nu h^{-1}_{11/2}$



$\pi h_{11/2}(g_{7/2}, d_{5/2}) \otimes \nu h^{-1}_{11/2}$

$\pi h_{11/2} g^{-1}_{7/2} \otimes \nu h^{-1}_{11/2}$



A. D. Ayangeakaa, et al, PRL 110, 172504 (2013)

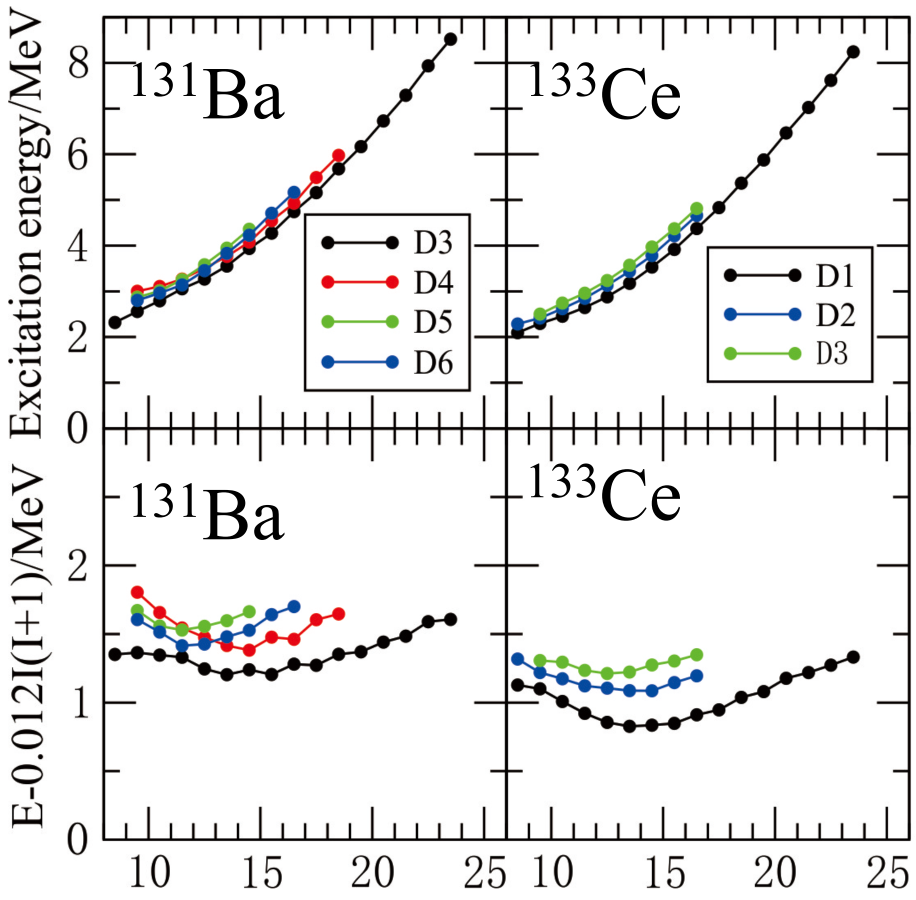
Observation

For the quartet bands, the energy difference of the chiral doublet involving the yrast band is larger than the pair of two yrare bands

If it is even larger, the chiral partner of the yrast band is out of identification experimentally, and triple bands is observed

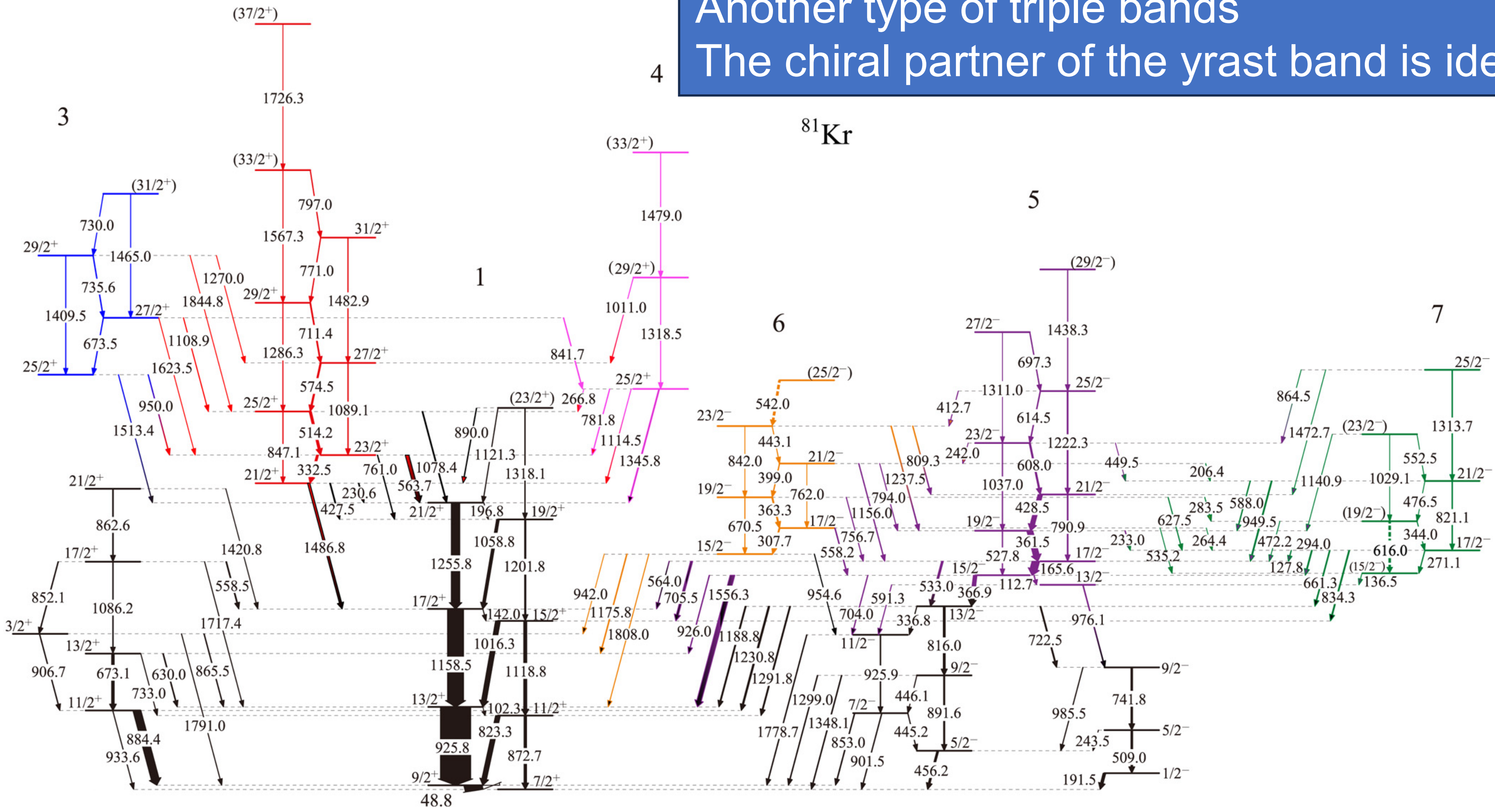
The energy difference of the yrast chiral doublet is sensitive to the number of proton or neutron

The mixture between $g_{7/2}$ and $d_{5/2}$ contribute to the stability of chirality?



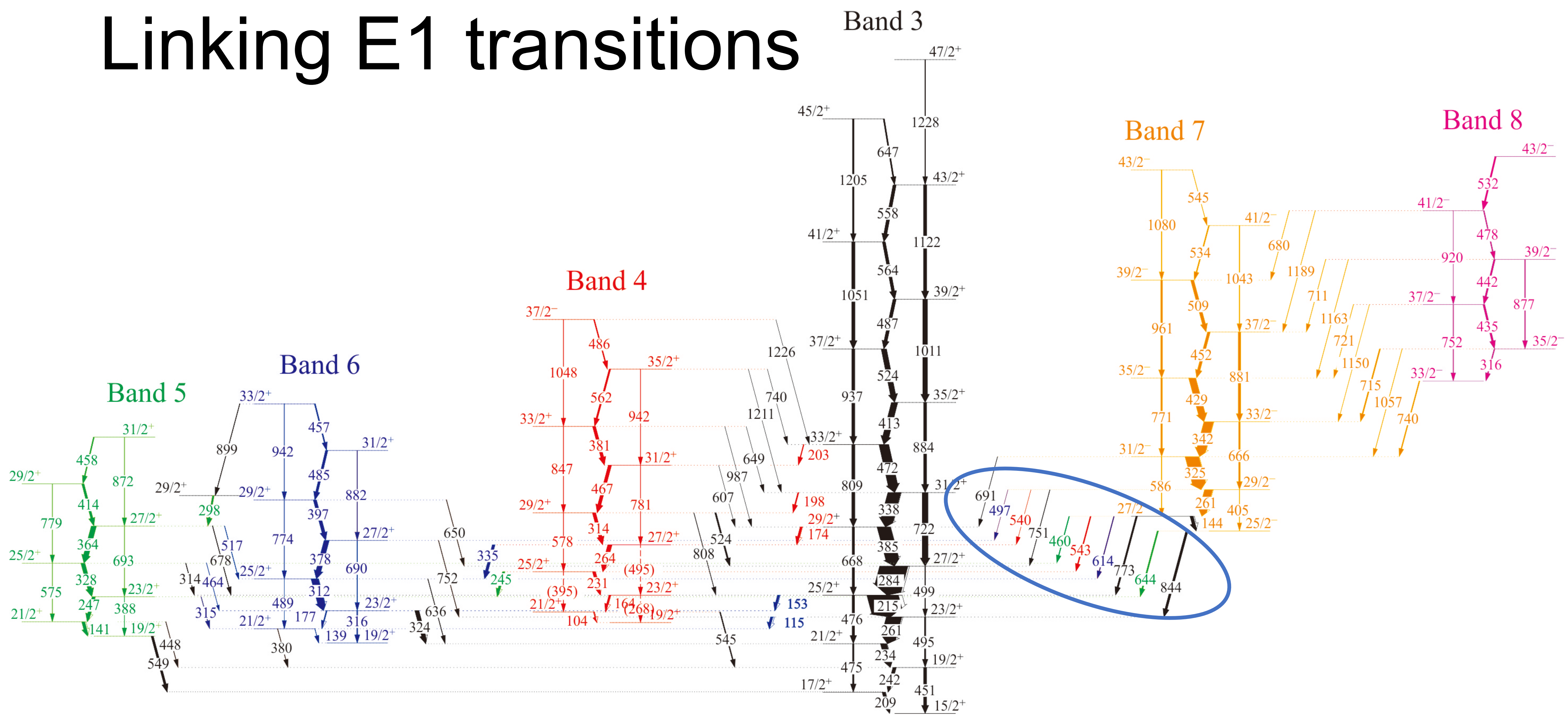
^{81}Kr

Another type of triple bands
The chiral partner of the yrast band is identified

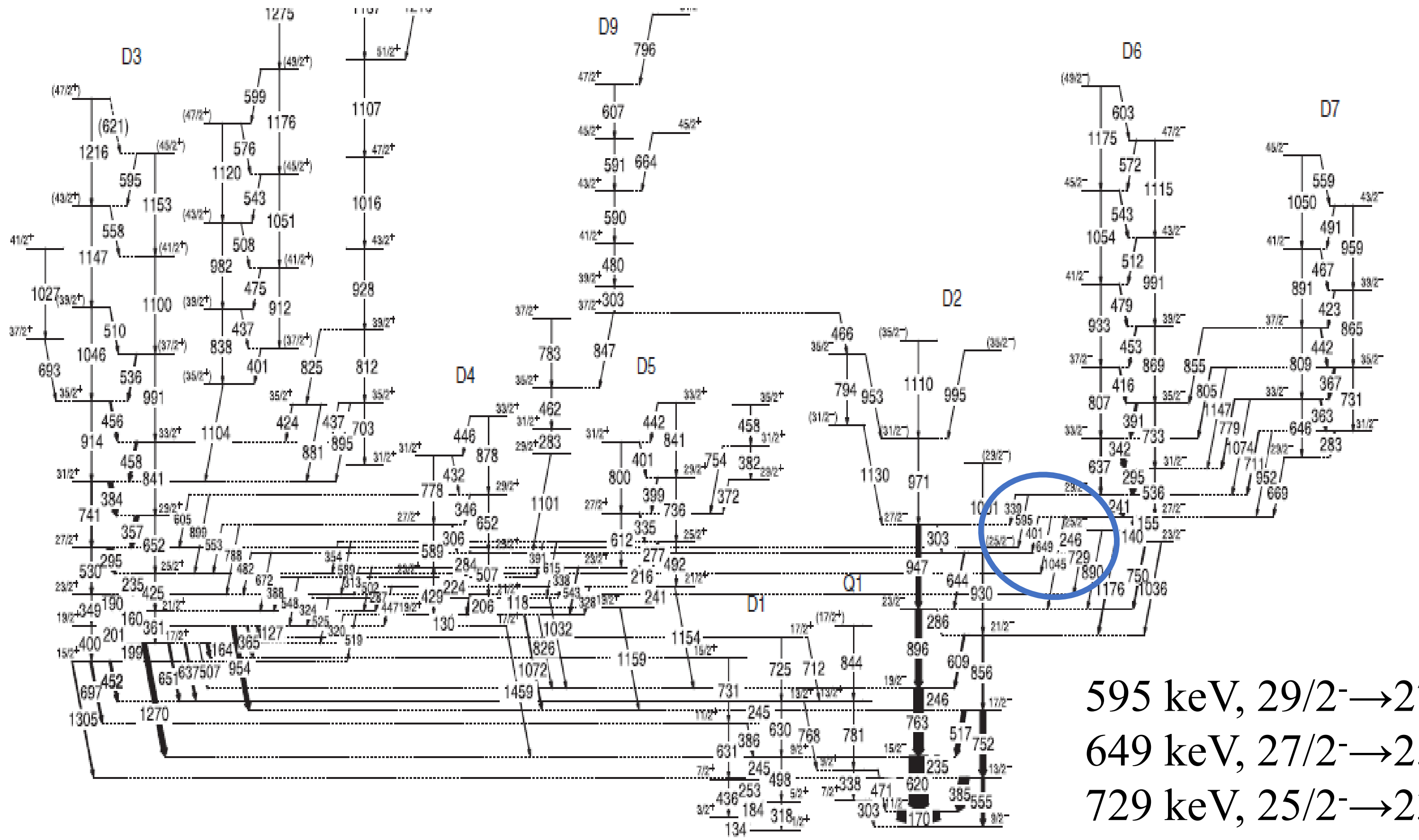


L. Mu, et al, PLB 827, 137006 (2022)

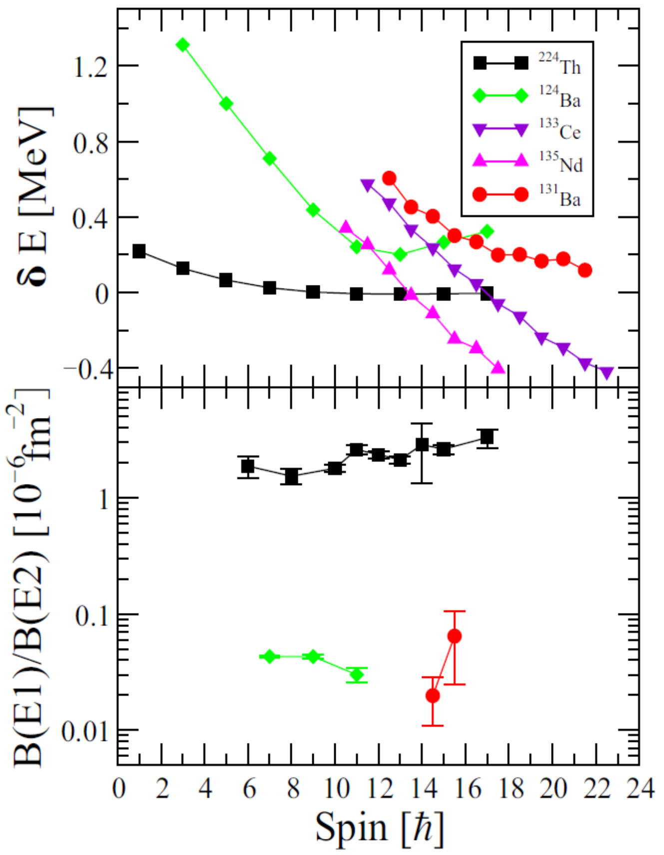
Linking E1 transitions



Linking E1 transitions in ^{133}Ce



595 keV, $29/2^- \rightarrow 27/2^+$
649 keV, $27/2^- \rightarrow 25/2^+$
729 keV, $25/2^- \rightarrow 23/2^+$



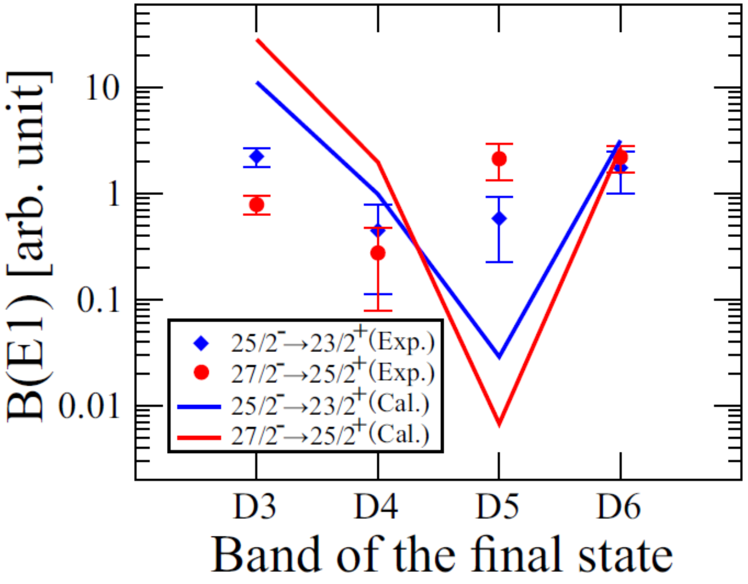
A. D. Ayangeakaa, et al, PRC 93, 054317 (2016)

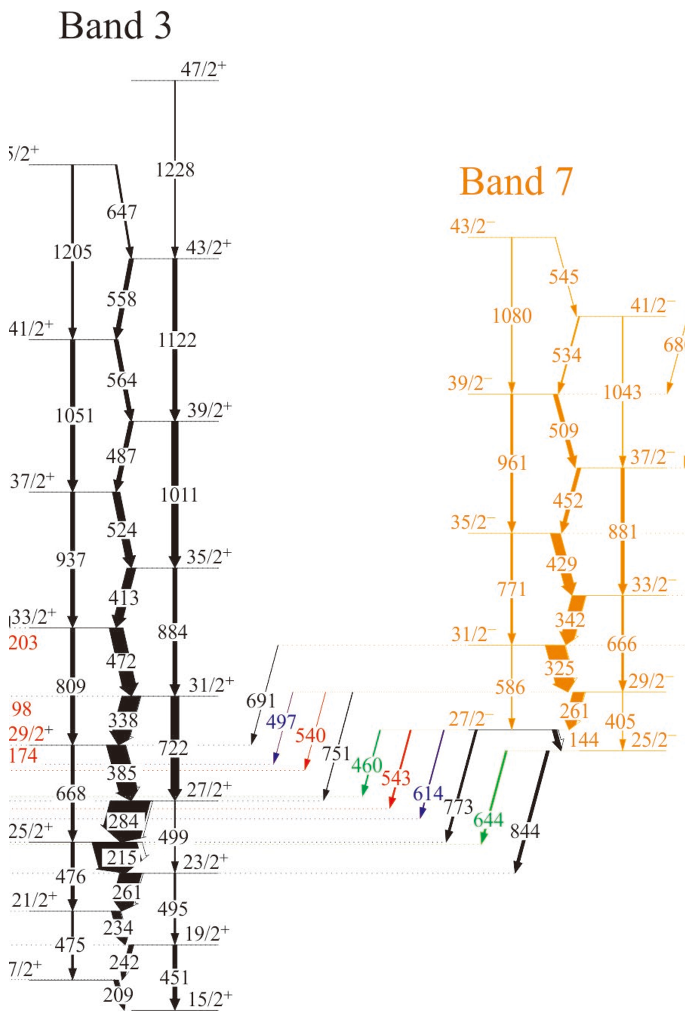
Look forward to related lifetime measurement

The relative intensity of the E1 transitions can be roughly, and not well produced by calculations

With lifetime information on the lowest four states of Band 7, it is possible to deduce B(E1) values

Chirality, pseudospin and octupole correlation are all involved to handle these measurable B(E1) values





Summary

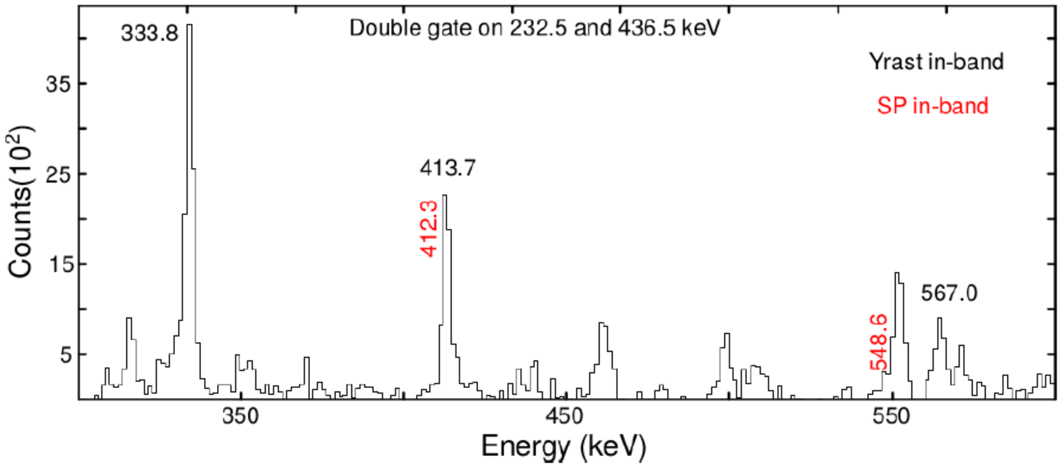
- First pseudospin-chiral quartet bands is reported
- From the reported quartet and triple systems, it is found that the energy difference of yrast chiral doublet is larger and sensitive to nucleon number
- Octupole correlation between two sets of chiral systems, with stronger and more complete linking transitions than those in neighboring isotones

A suggestion to public data in matrix format

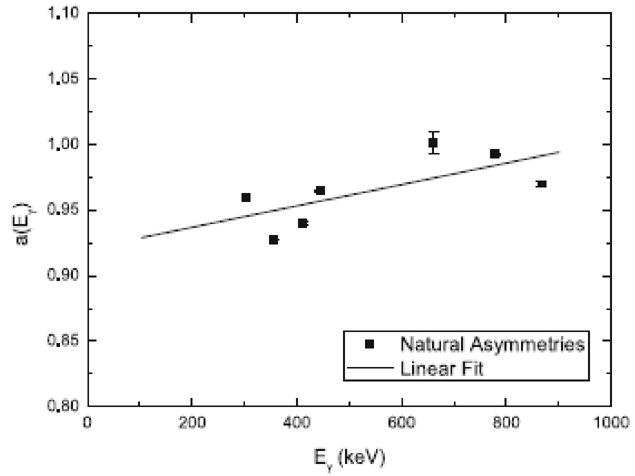
- Experimental physics relies on repeatability, but it is not easy to perform confirmatory experiments in high-spin gamma spectroscopy field
- Without public data, it is difficult to evaluate the reliability of experimental results
- For the feasibility of examining experimental results, it is more suitable to public matrix than raw data
- It may also promote to increase the participation of young people

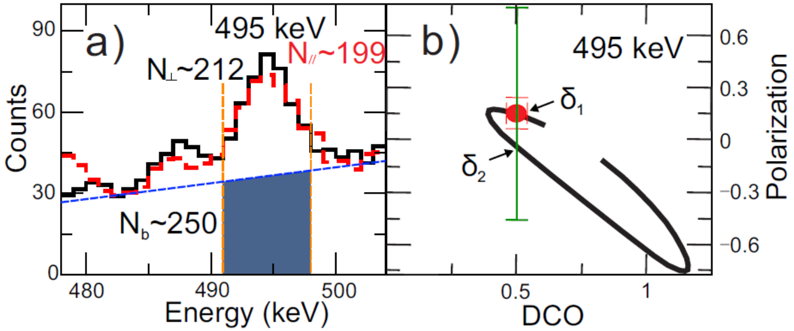
The problems on experimental data in gamma spectroscopy studies

- Identification of peaks in the ridge of another strong peak



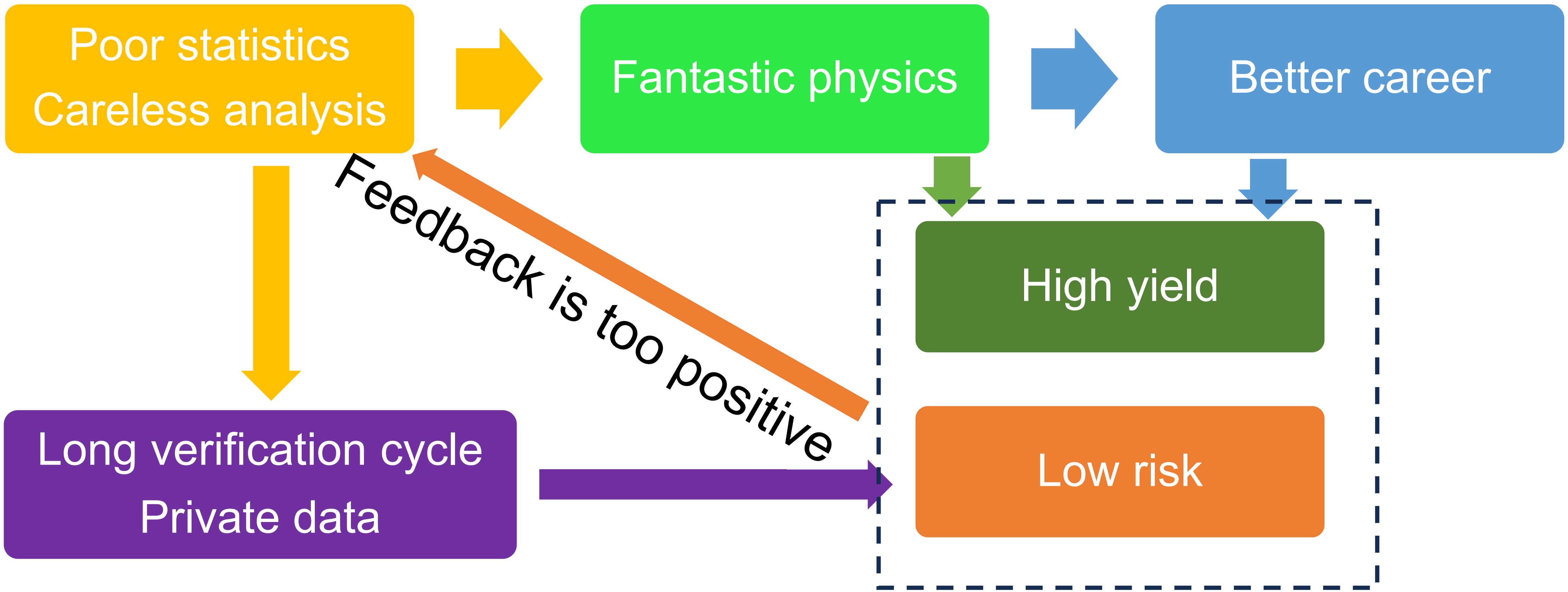
- Calibration line without meeting any point within errors





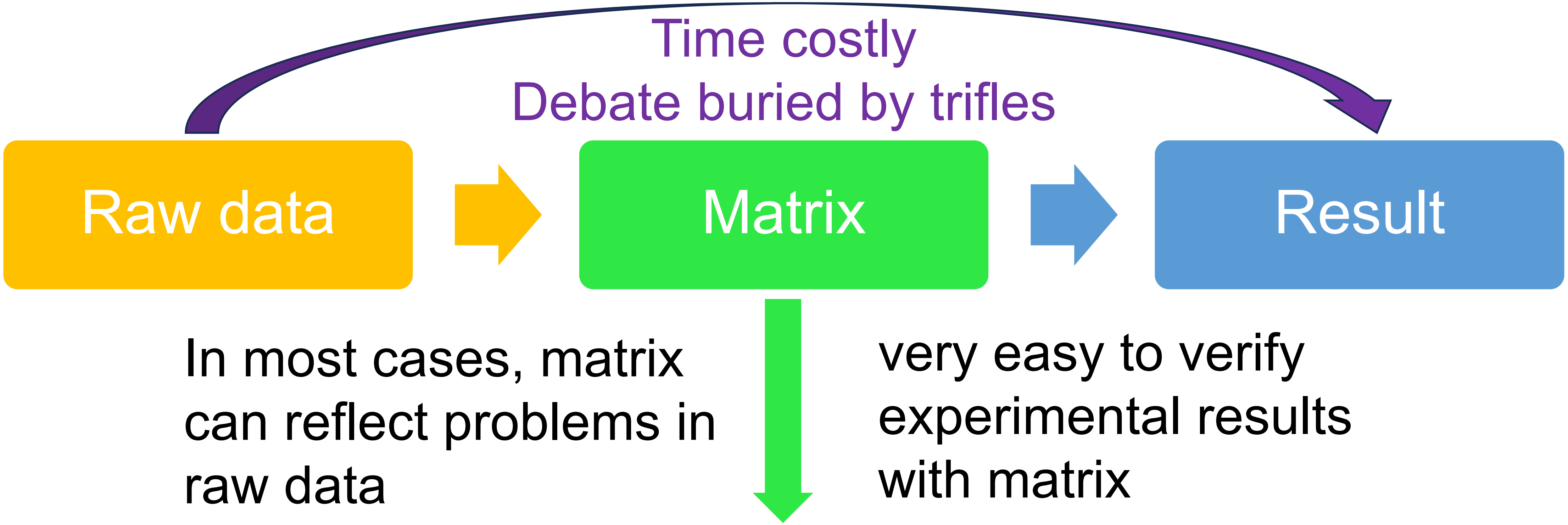
- Strunk error

Dangerous feedback



Try to break this cycle by effectively making data public

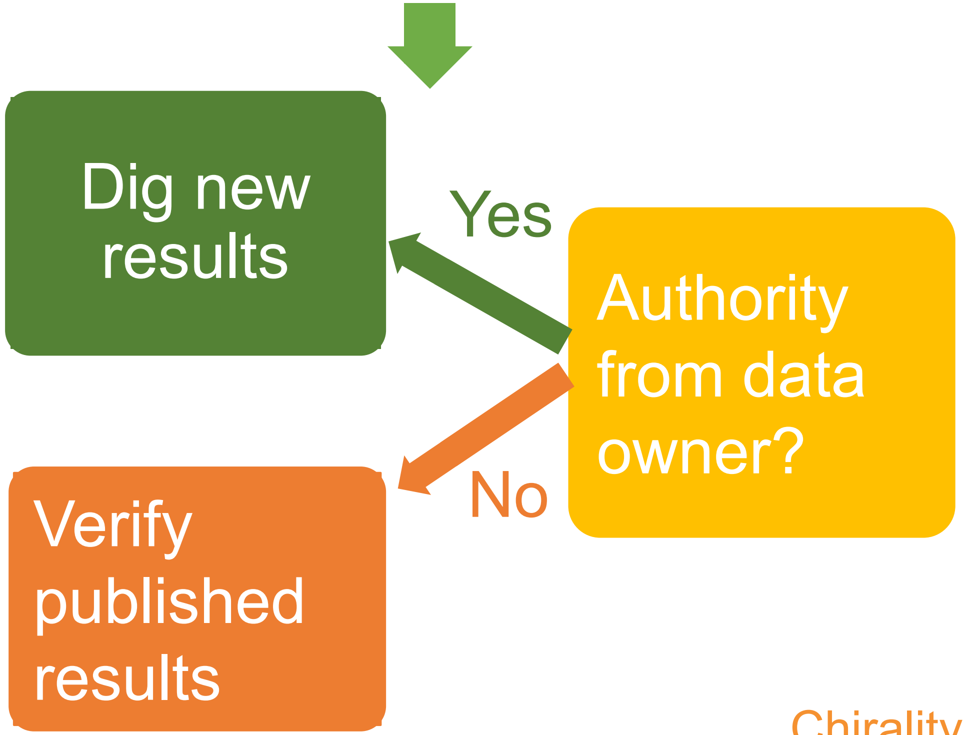
Matrix is better than raw data for sharing



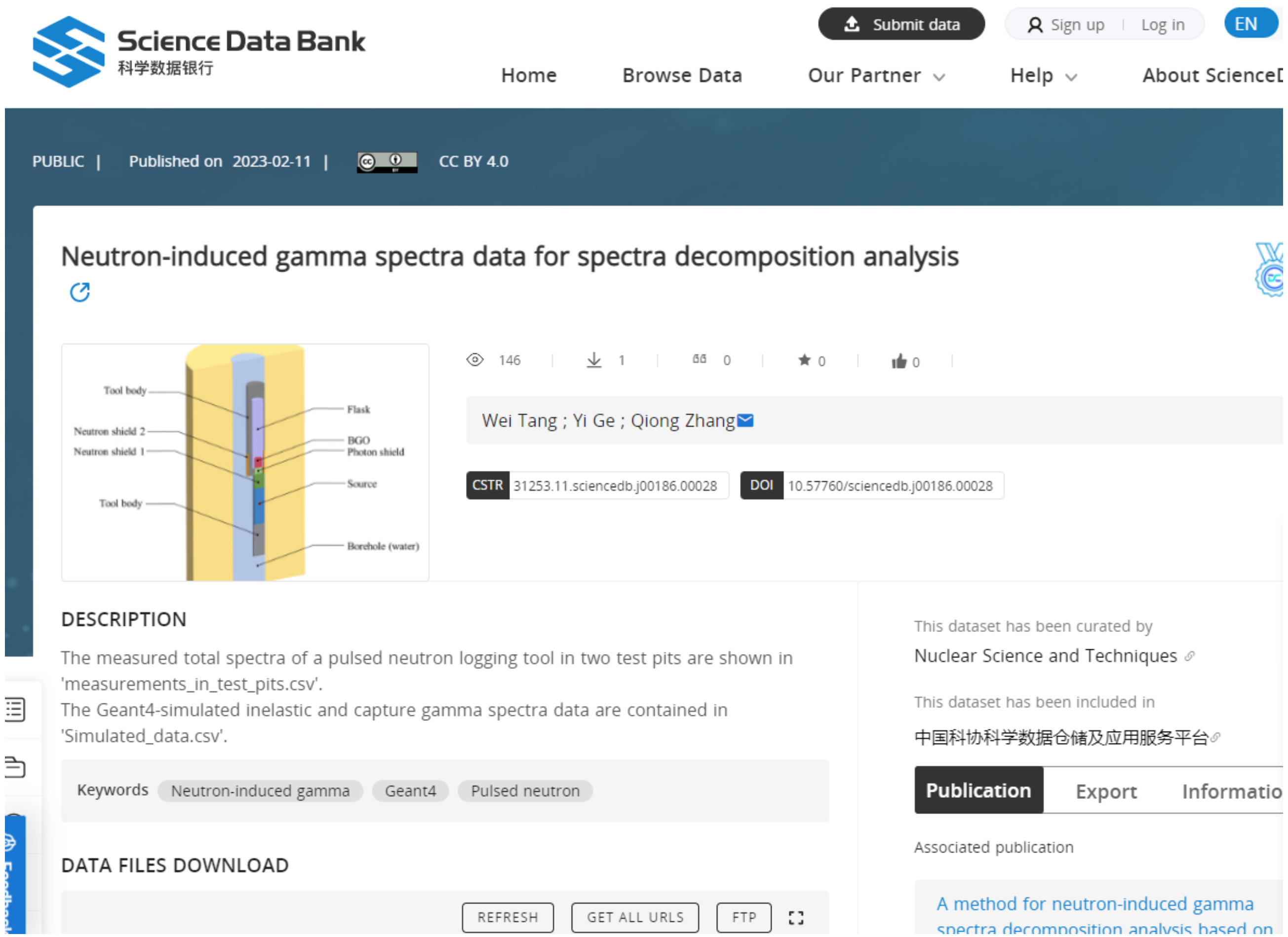
Universal formats
Easy to covert
Easy to establish standards of analysis

How?

- Free
- Independent doi number
- Flexible permission setting



https://www.scidb.cn/en



Allow studies evaluating published results

- Accept articles evaluating published results based on public matrix
- Set standards for such articles
- Open special column at some journal
- Allow some young people get their degree by doing such works

Route map

Non-mandatory

A few groups start to share their matrix
- And attract people to evaluate them

Sharing matrix turns to be more common slowly
- Especially to handle debates

Get to a common view:

Physics results should be reported based on verifiable public information

Editors and referees promote authors to share their matrix

Make better use of good data

- For some good data, only the main product was well analyzed
- There are potential results from the by-products
- Why not share?

For data owner

- Efforts need to be invested to make sure the data is not abused

For data user

- Only few persons can get the information and want to use it

→ by making matrix public →

Responsibility is clarified

Other persons can take on supervisory tasks

Open access

Easy to judge data quality

Who will benefit?

Data owner	Data user	Our field
• More reliable results • Be informed on mistakes • Better use of data	• More opportunity • Better training	• Improved reliability • Maintain good reputation • Long-living