Detailed spectroscopy of the neutron-deficient ^{193,195}Bi isotopes

Andrej Herzáň

UNIVERSITY OF JYVÄSKYLÄ
JYVÄSKYLÄN YLIOPISTO

UNIVERSITY OF LIVERPOOL

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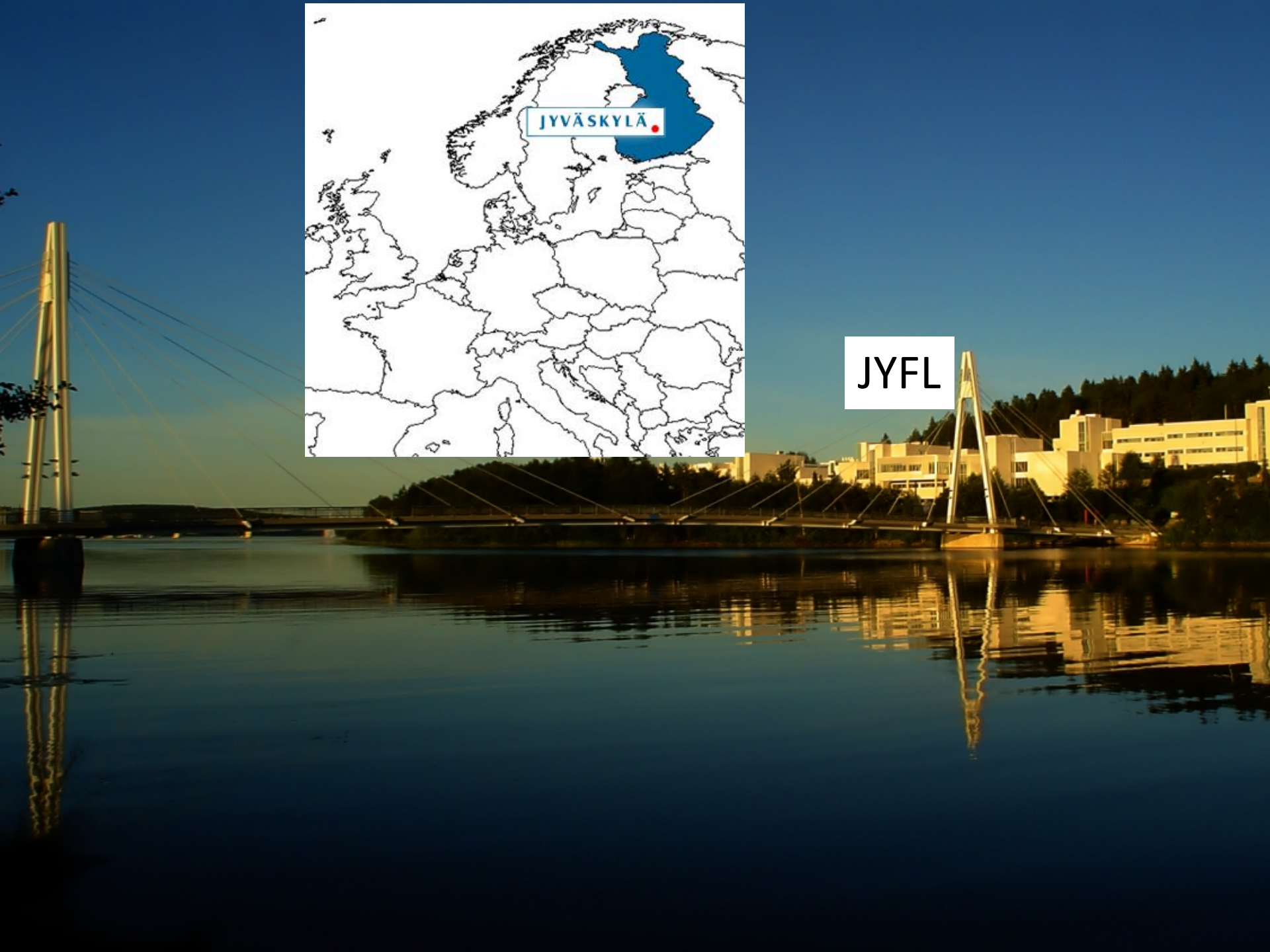
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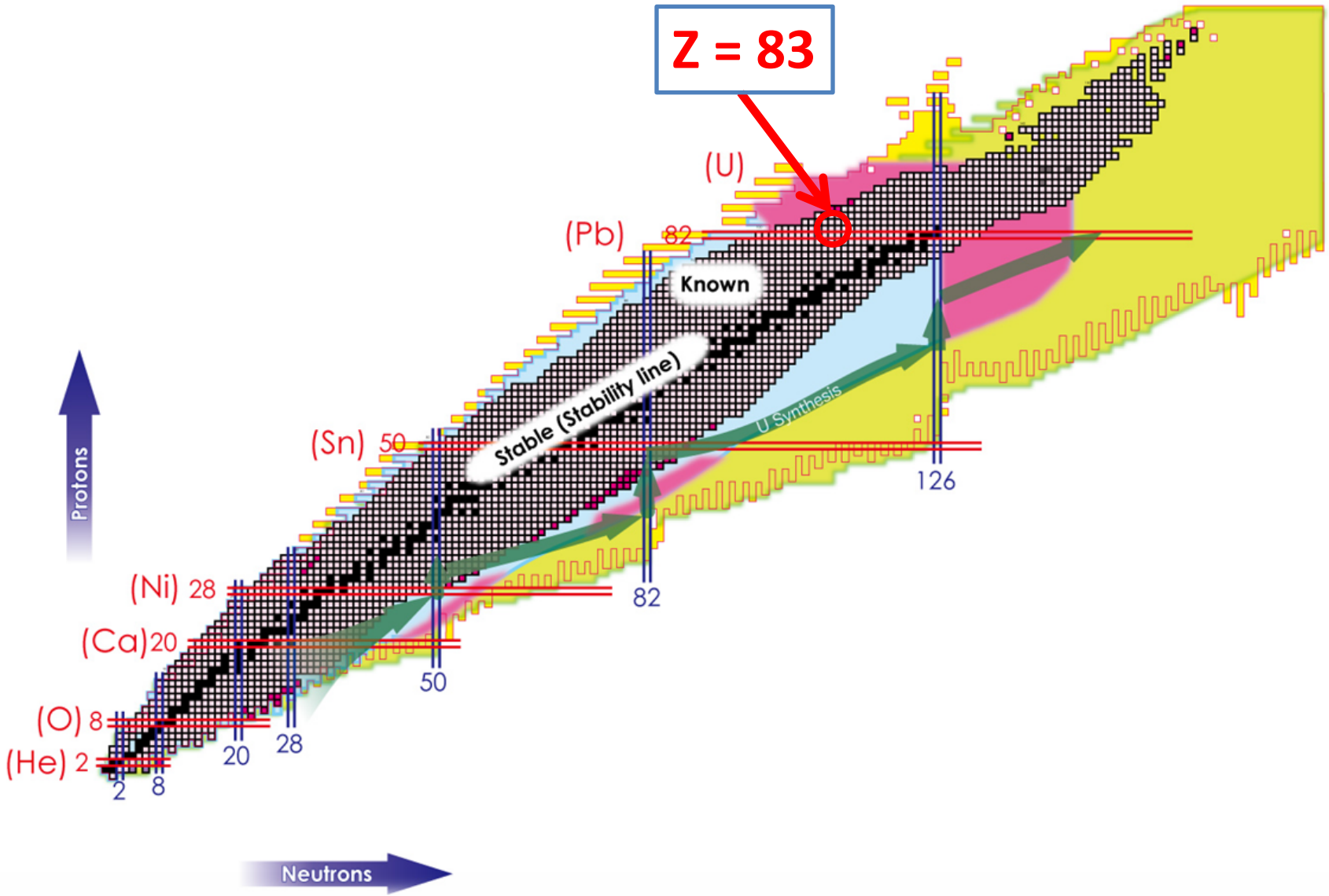
Motivation

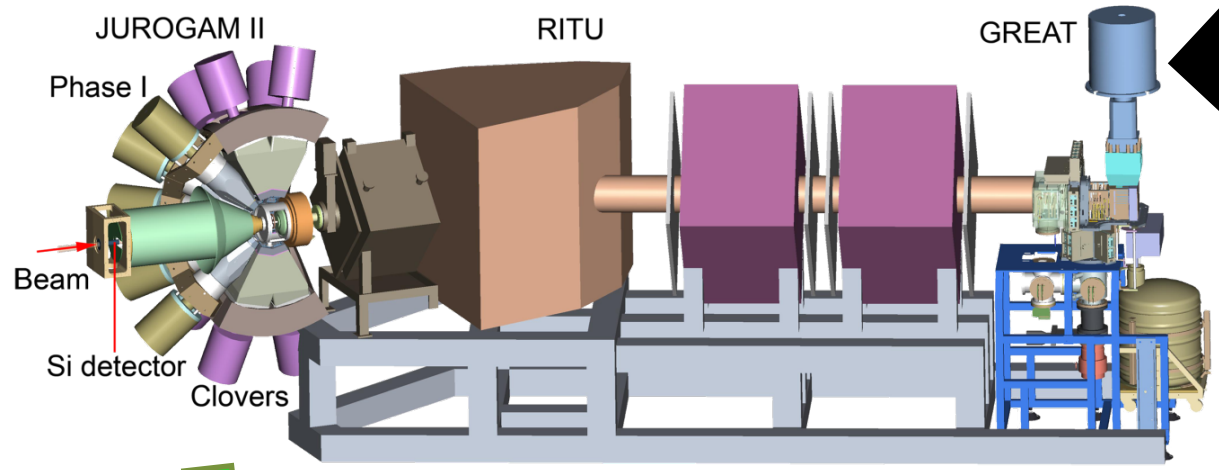
- Investigation of the shape coexistence in the vicinity of Pb core with magic Z = 82 number, where Bi is a „unique tool“ for such studies.

- Study of the isomeric states built on multi-quasiparticle configurations

- Searching for highly excited superdeformed bands in this region for better understanding of nuclear properties under extreme deformation, their formation, de-excitation etc.

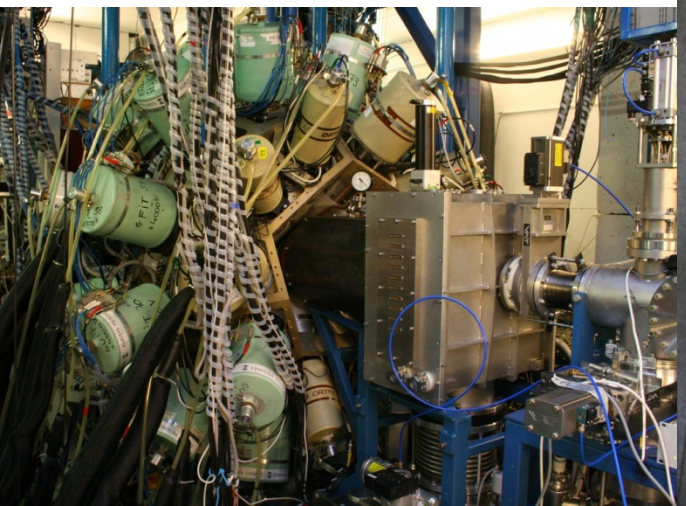

Z = 83
(U)
(Pb) 82
Known
Stable (Stability line)
U Synthesis
(Sn) 50
(Ni) 28
(Ca) 20
(O) 8
(He) 2
2
8
20
28
50
82
126
Protons
Neutrons

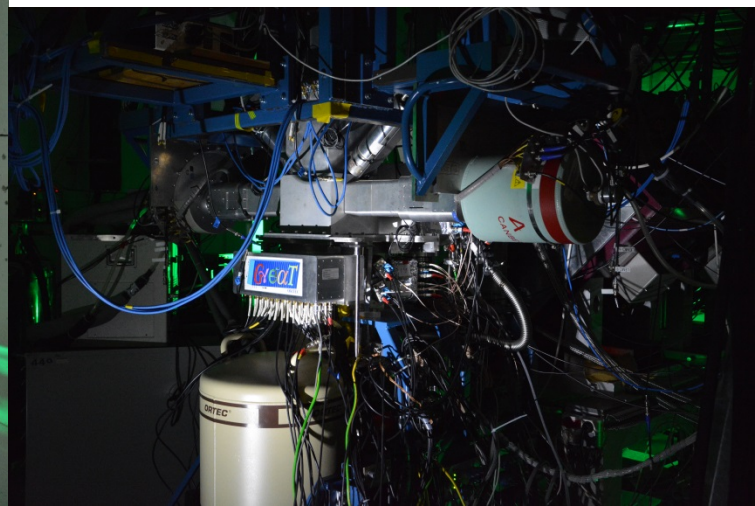
The experiments



I. $^{165}Ho(^{32}S,4n)^{193}Bi$, E_b = 152 MeV

II. $^{159}Tb(^{40}Ar,4n)^{195}Bi$, E_b = 175 MeV





PHYSICAL REVIEW C **69**, 064326 (2004)

γ-ray spectroscopy of ^{191,193}Bi

P. Nieminen,[1] S. Juutinen,[1] A. N. Andreyev,[2,3] J. F. C. Cocks,[1] O. Dorvaux,[1,*] K. Eskola,[4] P. T. Greenlees,[1] K. Hauschild,[5,†] K. Helariutt[1,‡] M. Huyse,[2] P. M. Jones,[1] R. Julin,[1] H. Kankaanpää,[1] H. Kettunen,[1] P. Kuusiniemi,[1] Y. Le Coz,[5] M. Leino,[1] T. [illegible] M. Muikku,[1,§] P. Rahkila,[1] A. Savelius,[1] J. Uusitalo,[1] N. Amzal,[3] N. J. Hammond,[3,‖] C. Scholey,[3,1] and R. Wyss[7]

[illegible]rtment of Physics, P. O. Box 35 (YFL), FIN-40014 University of Jyväskylä, Finland
[2]Instituut voor Kern- en Stralingsfysica, K.U. Leuven, Leuven, Belgium
Oliver Lodge Laboratory, University of Liverpool, Liverpool, United Kingdom
[4]Department of Physical Sciences, University of Helsinki, Helsinki, Finland
[5]DAPNIA/SPhN, CEA Saclay, France
[6]Department of Physics, Åbo Akademi, Turku, Finland
[7]Physics Department, The Royal Institute of Technology, Stockholm, Sweden

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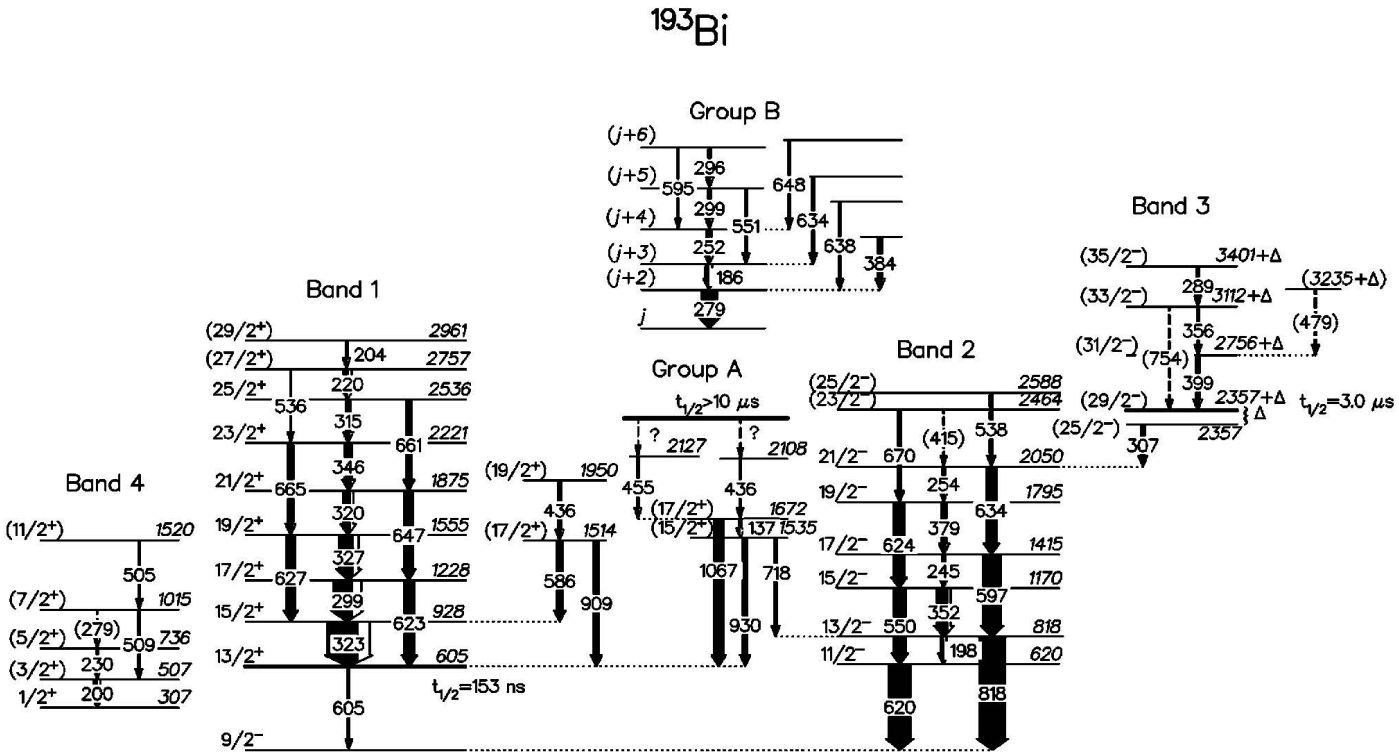
Results of previous studies

Prompt and delayed γ rays from ^{191,193}Bi have been identified using the recoil-decay tagging, isomer tagging, and recoil gating techniques, resulting in extensive level schemes for both nuclei. Excitation energies of the isomeric $13/2^+$ states have been established and oblate strongly coupled bands built on them have been



PHYSICAL REVIEW C VOLUME 33, NUMBER 5 MAY 1986

Excited states in neutron-deficient ^{195}Bi

T. Lönnroth,* C. W. Beausang, D. B. Fossan, L. Hildingsson,†
W. F. Piel, Jr., M. A. Quader, and S. Vajda
Department of Physics, State University of New York, Stony Brook, New York 11794

T. Chapuran
Department of Physics, University of Pennsylvania, Philadelphia, Pennsylvania 19104

E. K. Warburton
Department of Physics, Brookhaven National Laboratory, Upton, New York 11973
(Received 19 December 1985)

PHYSICAL REVIEW C **85**, 064317 (2012)

Onset of deformation at $N = 112$ in Bi nuclei

H. Pai,[1] G. Mukherjee,[1,*] R. Raut,[2,†] S. K. Basu,[1] A. Goswami,[2] S. Chanda,[1,‡] T. Bhattacharjee,[1] S. Bhattacharyya,[1] C. Bhattacharya,[1] S. Bhattacharya,[1] S. R. Banerjee,[1] S. Kundu,[1] K. Banerjee,[1] A. Dey,[1] T. K. Rana,[1] J. K. Meena,[1] D. Gupta,[1,§] S. Mukhopadhyay,[1] Srijit Bhattacharya,[1,‖] Sudeb Bhattacharya,[2] S. Ganguly,[2,¶] R. Kshetri,[2] and M. K. Pradhan[2]
[1]*Variable Energy Cyclotron Centre, 1/AF Bidhan Nagar, Kolkata 700064, India*
[2]*Saha Institute of Nuclear Physics, Kolkata 700064, India*
(Received 24 November 2011; revised manuscript received 25 March 2012; published 20 June 2012)

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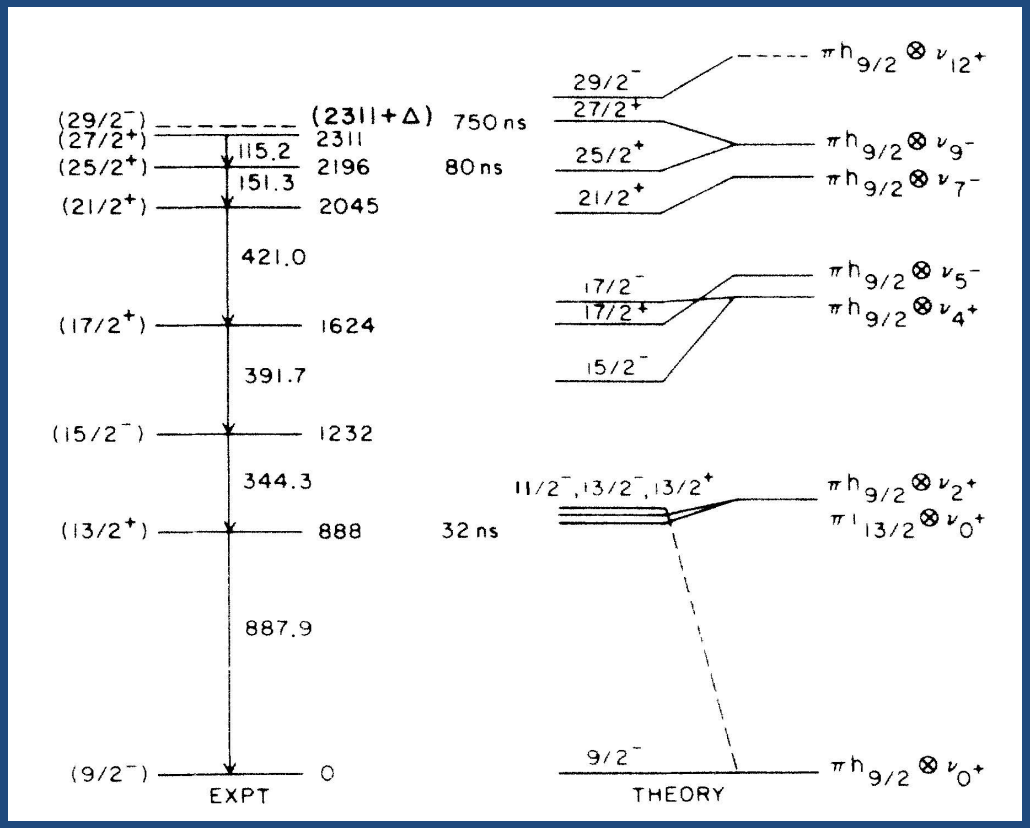
THE EUROPEAN PHYSICAL JOURNAL A

Regular Article – Experimental Physics

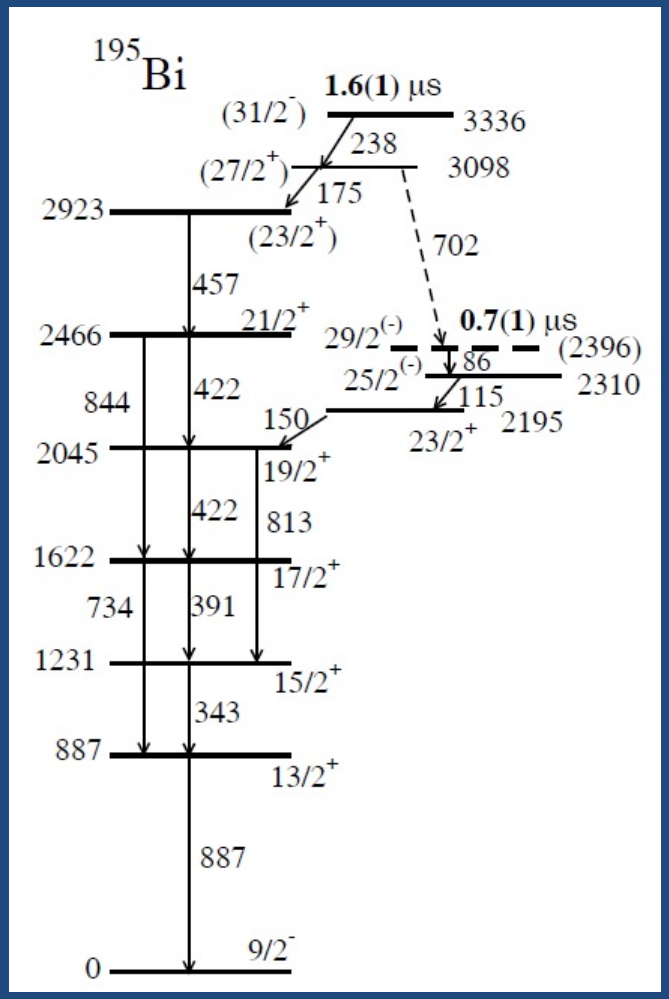
A new high-spin isomer in ^{195}Bi

T. Roy[1], G. Mukherjee[1,a], N. Madhavan[2], T.K. Rana[1], Soumik Bhattacharya[1], Md.A. Asgar[1], I. Bala[2], K. Basu[3], S.S. Bhattacharjee[3], C. Bhattacharya[1], S. Bhattacharya[1,b], S. Bhattacharyya[1], J. Gehlot[2], S.S. Ghugre[3], R.K. Gurjar[2], A. Jhingan[2], R. Kumar[2], S. Muralithar[2], S. Nath[2], H. Pai[1,c], R. Palit[4], R. Raut[3], R.P. Singh[2], A.K. Sinha[3], and T. Varughese[2]

[1] Variable Energy Cyclotron Centre, Kolkata 700064, India
[2] Inter University Acclerator Centre, Aruna Asaf Ali Marg, New Delhi 110067, India
[3] UGC-DAE-CSR Kolkata Centre, SectorIII/LB-8 Bidhan Nagar, Kolkata 700098, India
[4] Department of Nuclear and Atomic Physics, Tata Institute of Fundamental Research, Mumbai 400005, India



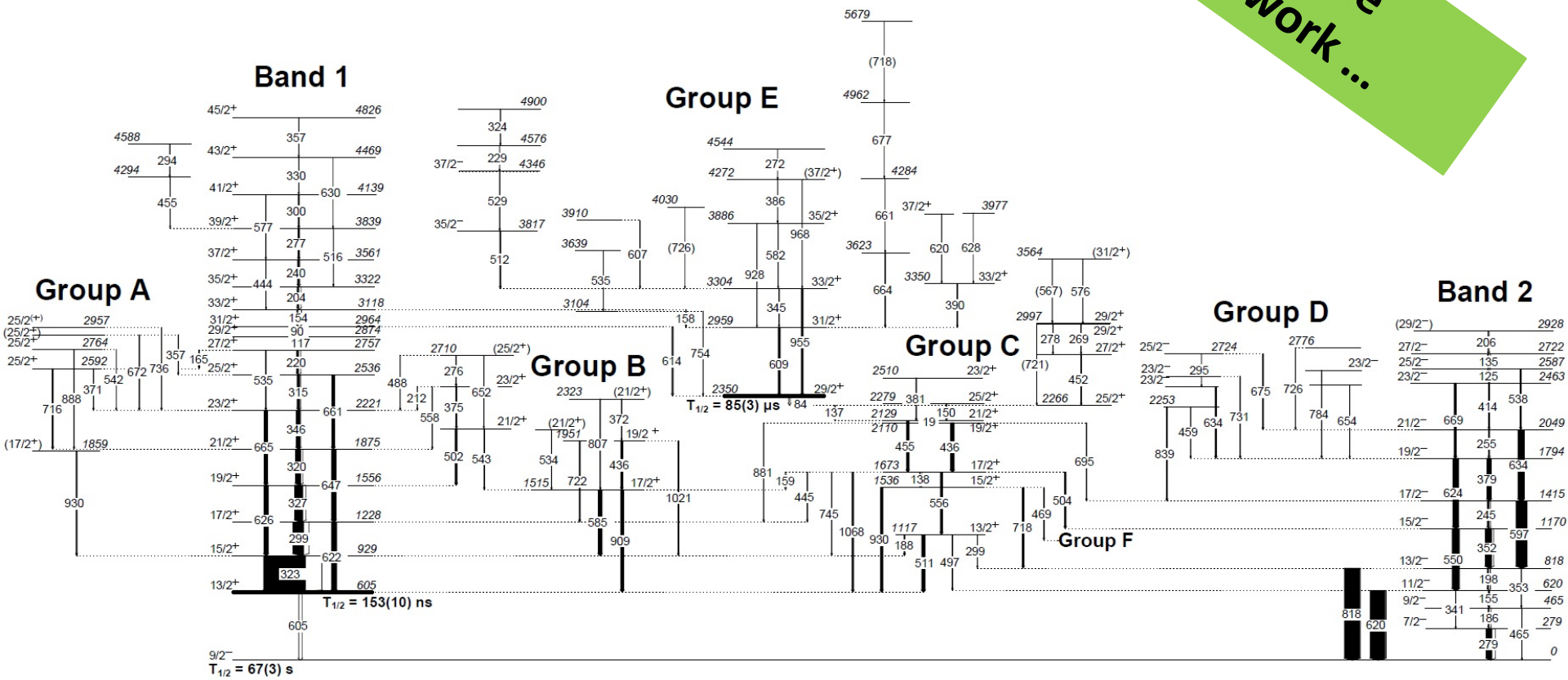
Lönnroth *et al*., Phys. Rev. **C** Vol. **33**, No. 5 (1986)



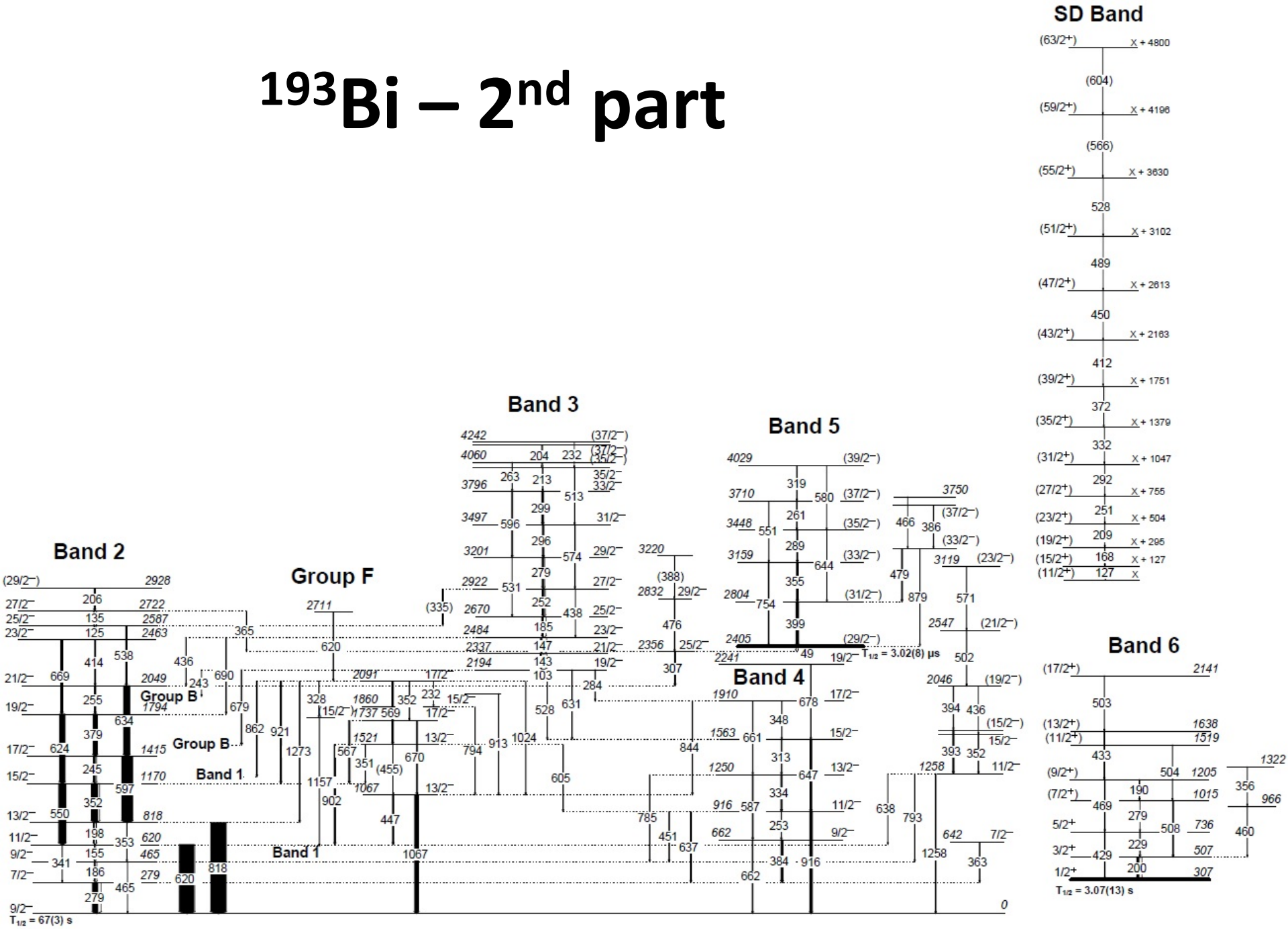
Roy *et al*., Eur. Phys. J. **A 51**, 153 (2015)

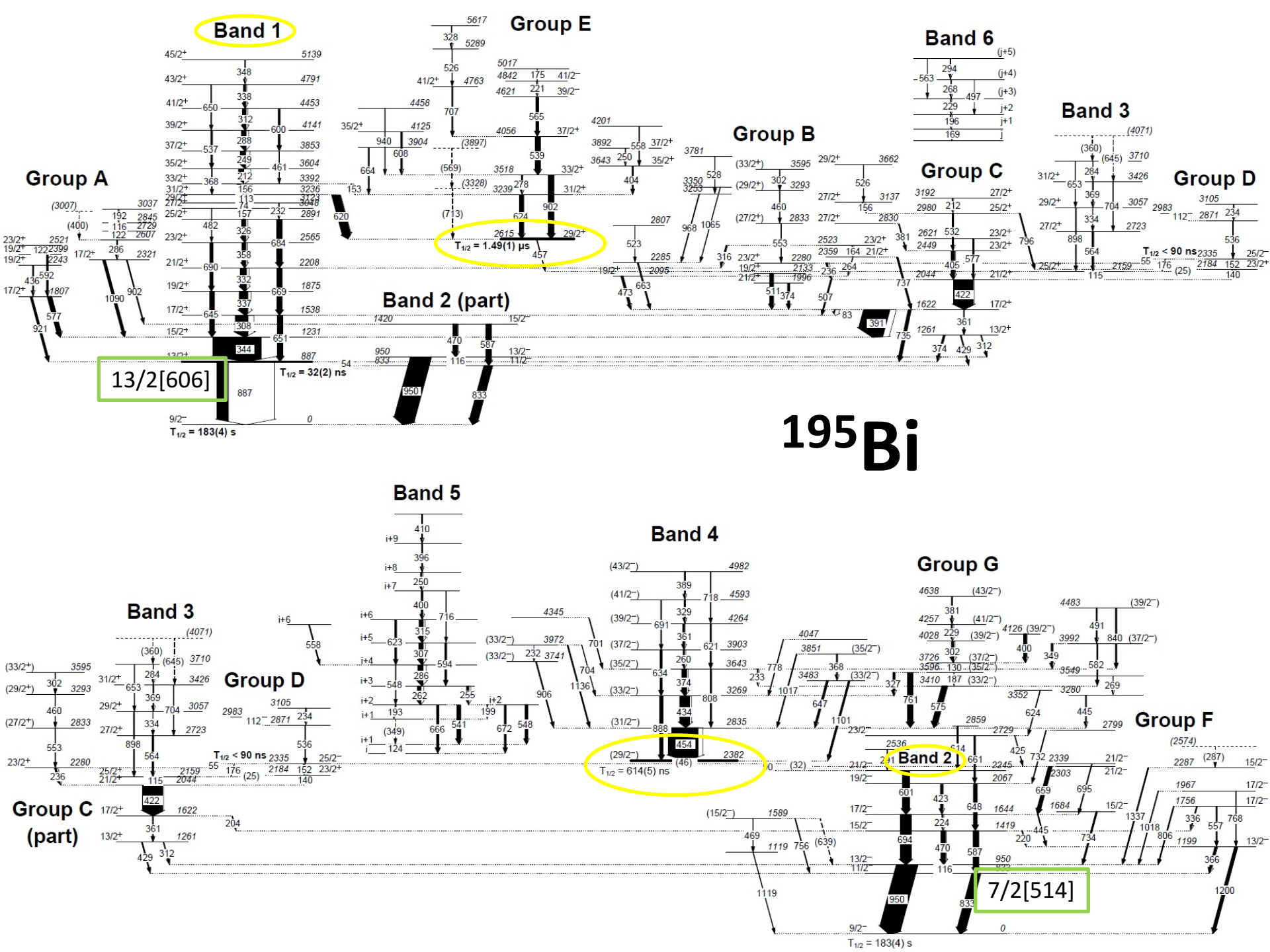
^{193}Bi - 1st part

Results of the present work ...

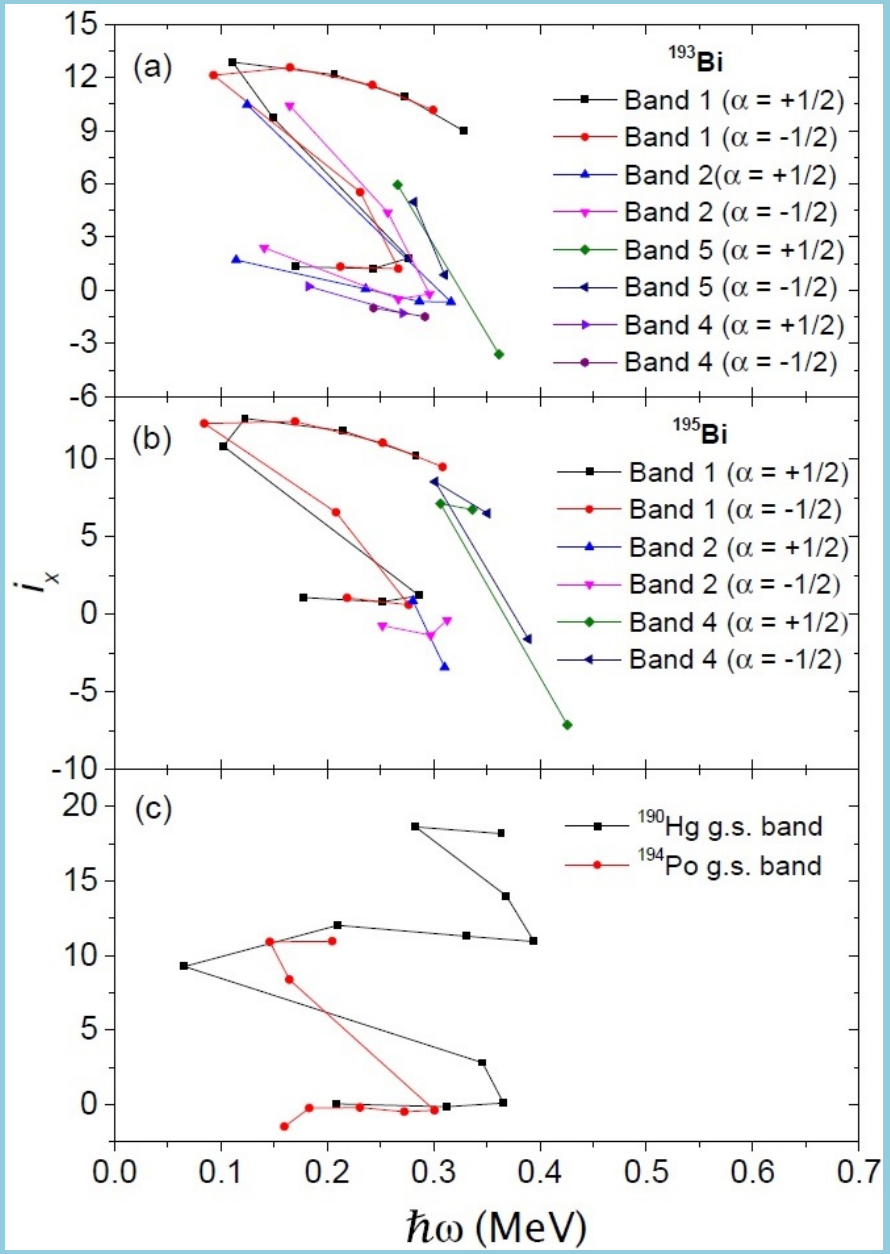


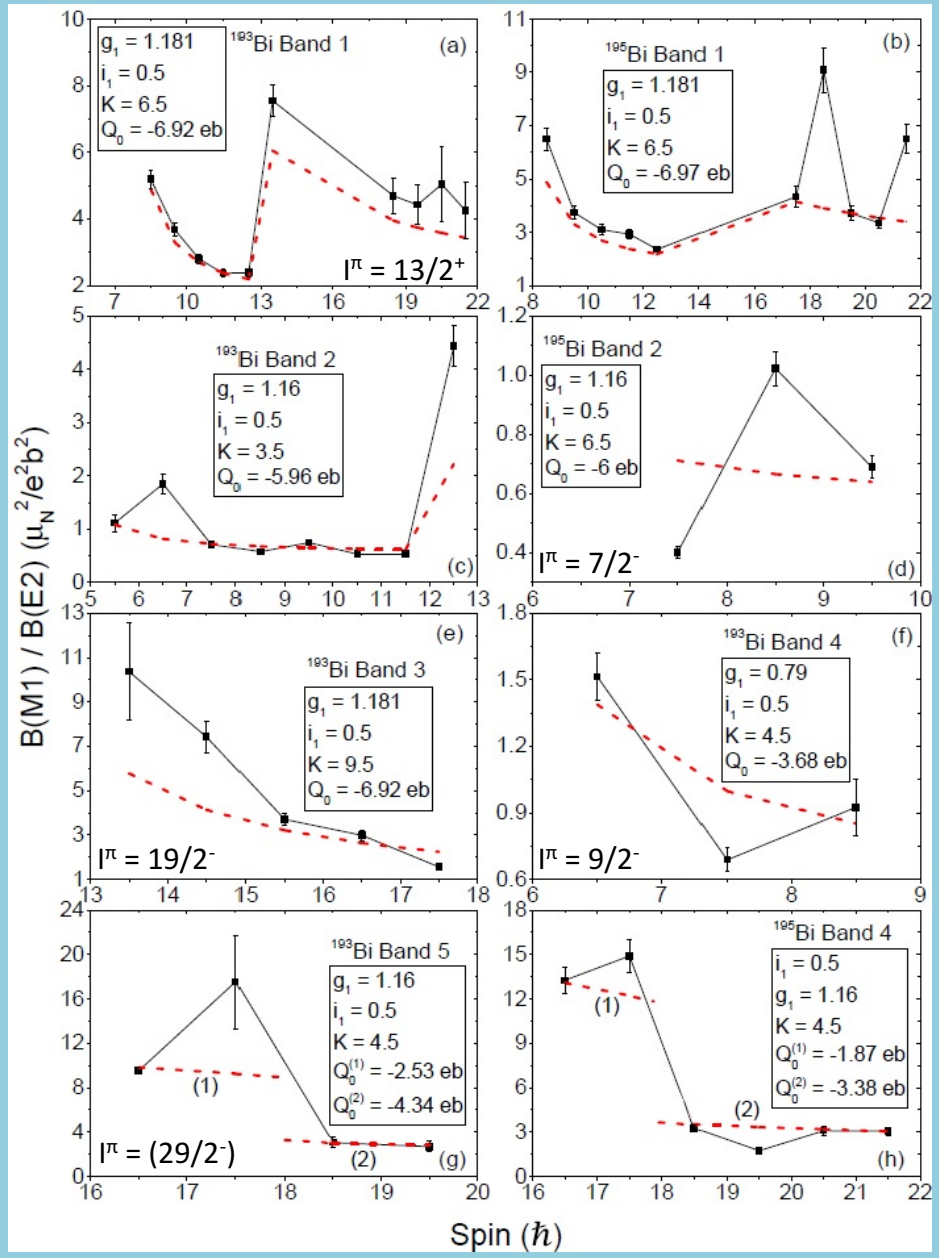
^{193}Bi – 2nd part



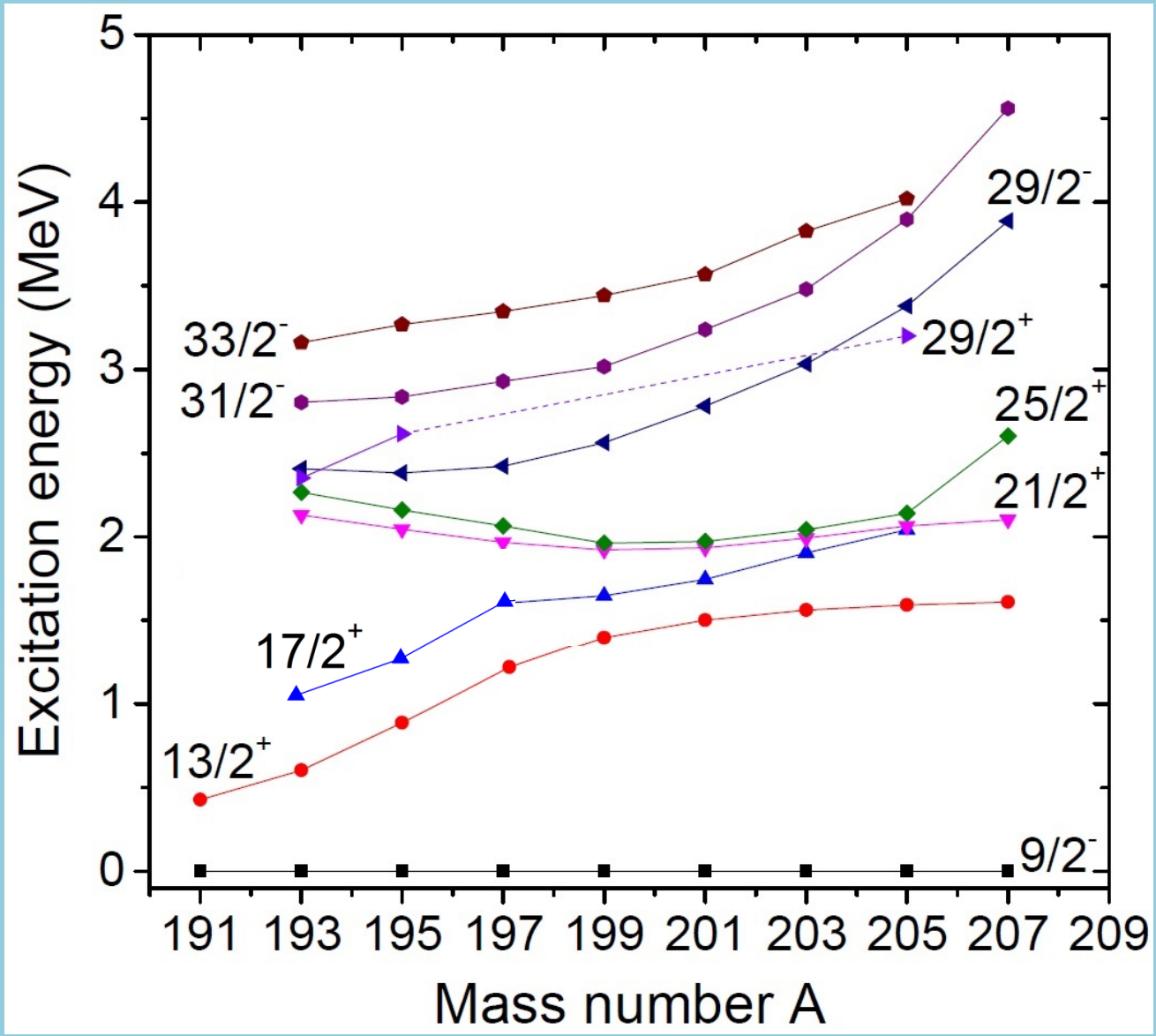

Band 1
Group E
Band 6
Band 3
Group A
Group B
Group C
Group D
Band 2 (part)
13/2[606]
$T_{1/2}$ = 32(2) ns
$T_{1/2}$ = 183(4) s
$T_{1/2}$ = 1.49(1) μs
$T_{1/2}$ < 90 ns
195Bi
Band 5
Band 4
Group G
Group F
Band 3
Group D
Group C (part)
Band 2
$T_{1/2}$ = 614(5) ns
$T_{1/2}$ < 90 ns
$T_{1/2}$ = 183(4) s
7/2[514]

Rotational bands analysis





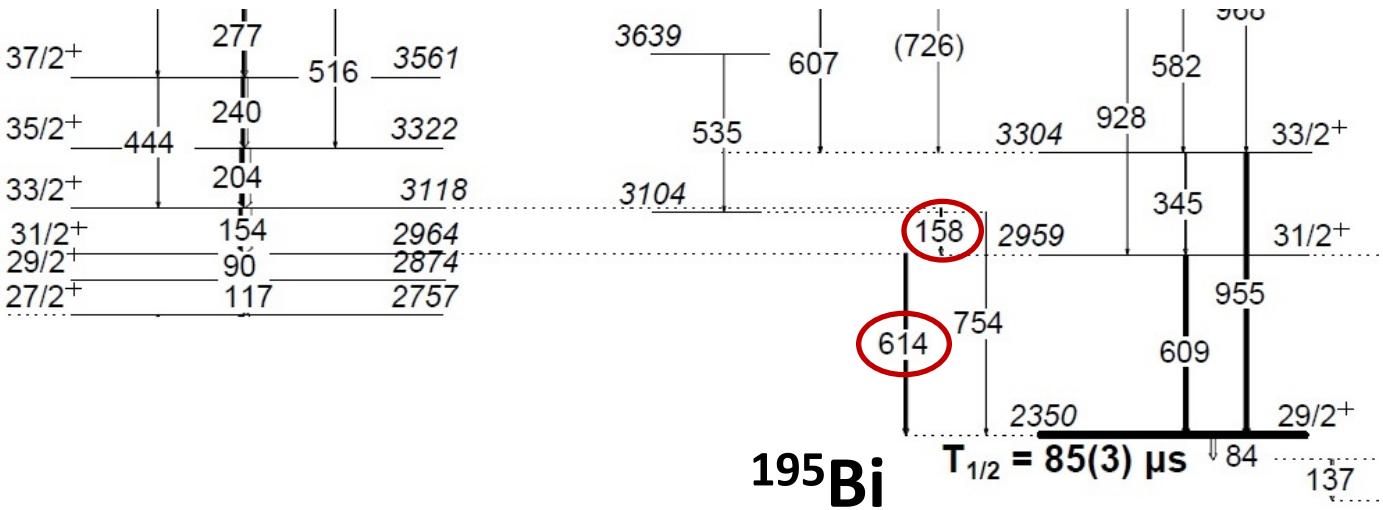
High-spin Isomeric states



$29/2^+$ isomeric state

$\pi i_{13/2}\, \nu(i_{13/2})^2$

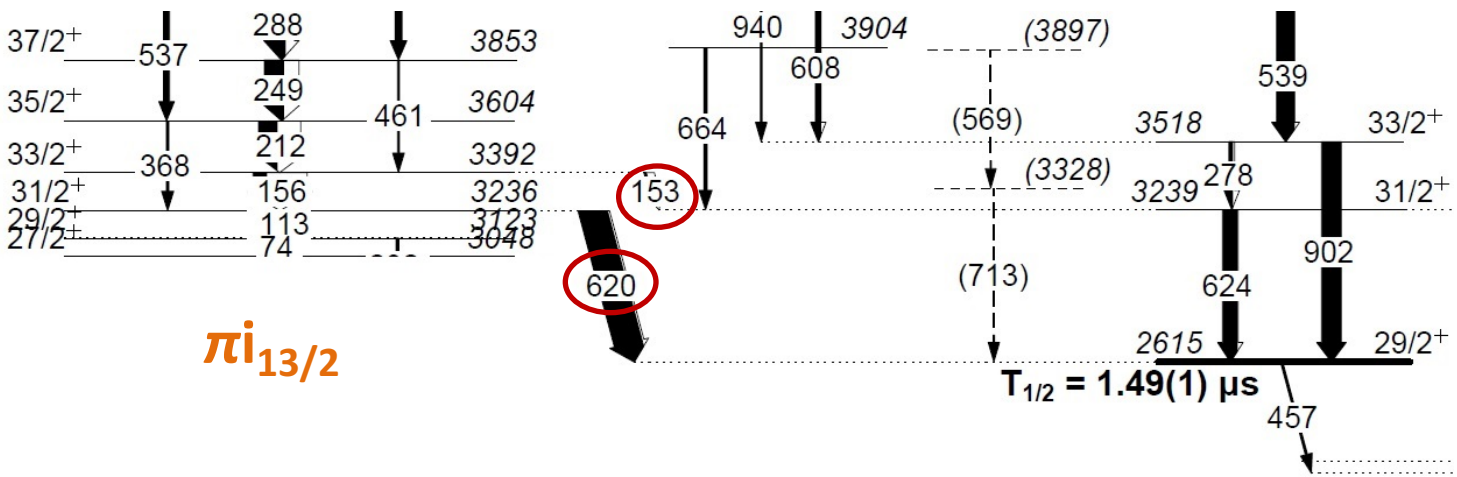
^{193}Bi



V = 1.3 keV
ΔE_p = 5 keV
ΔE_u = 4.27 keV

$\pi i_{13/2}(h_{9/2})^2$

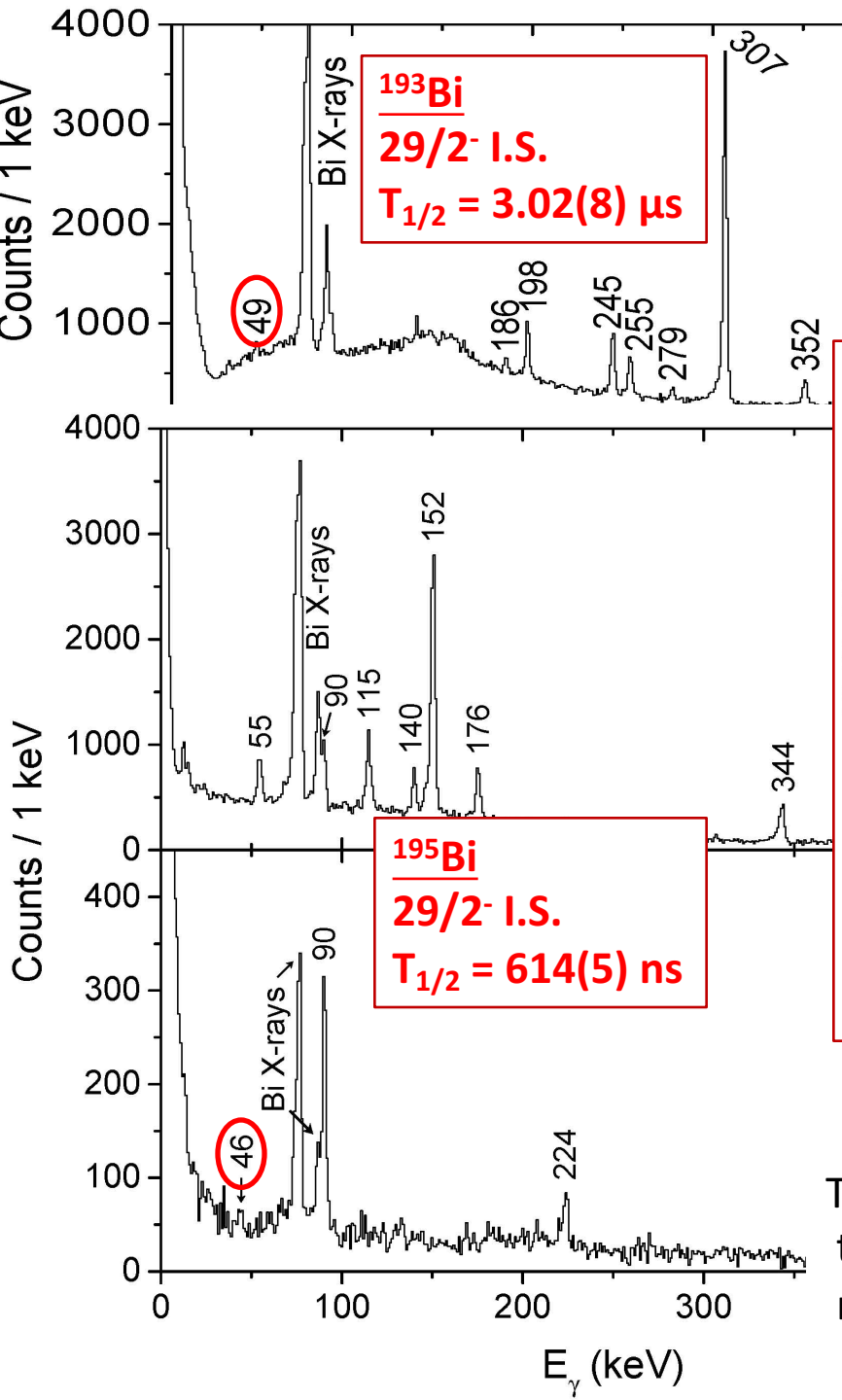
^{195}Bi



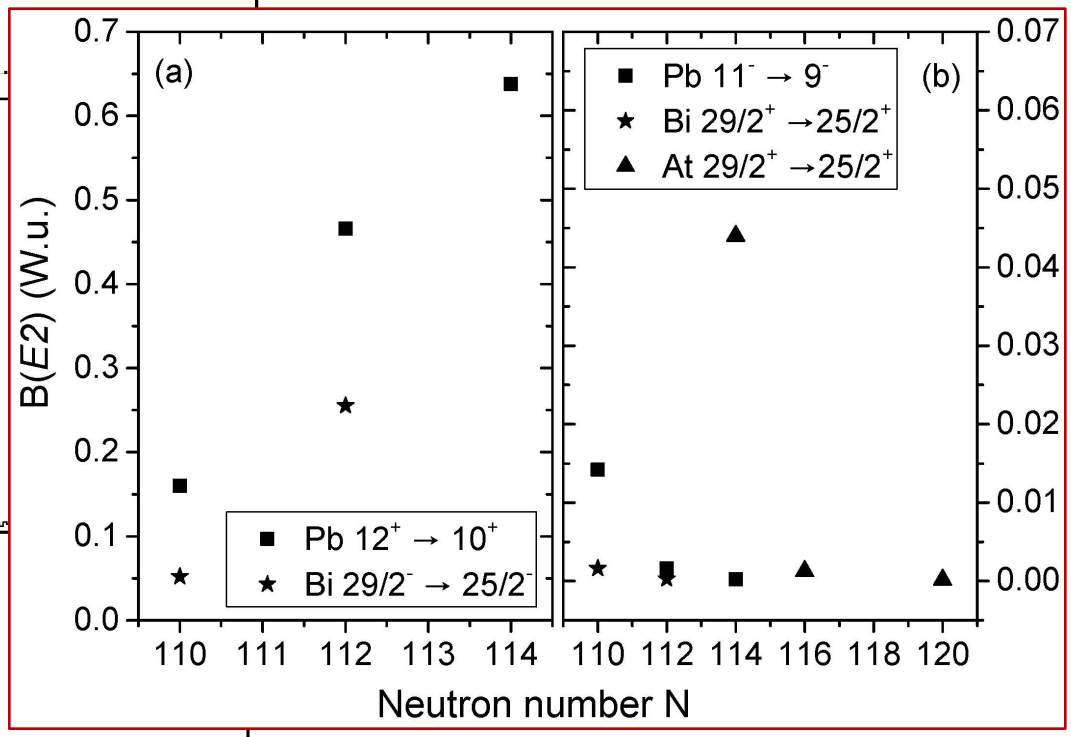
V = 1.1 keV
ΔE_p = 3 keV
ΔE_u = 2.03 keV

$\pi i_{13/2}$

$\pi i_{13/2}(h_{9/2})^2$



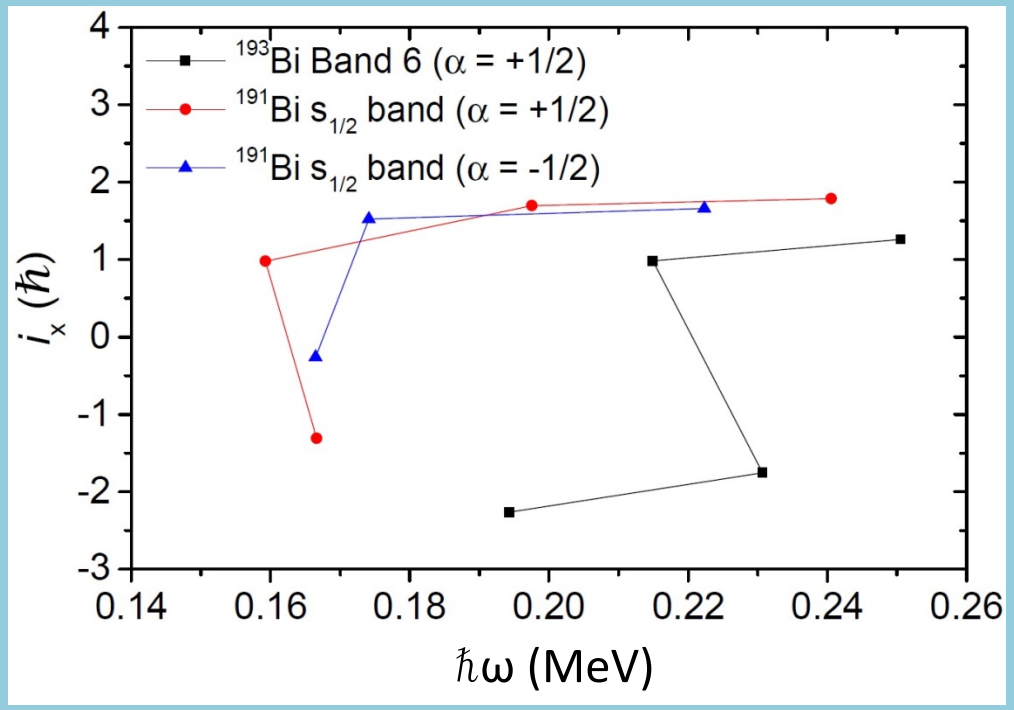
The spectrum of γ rays detected in the planar detector and in coincidence with the $\pi(h_{9/2}/f_{7/2})$ band transitions detected in the FP clover detectors within 15 μs in ^{193}Bi.

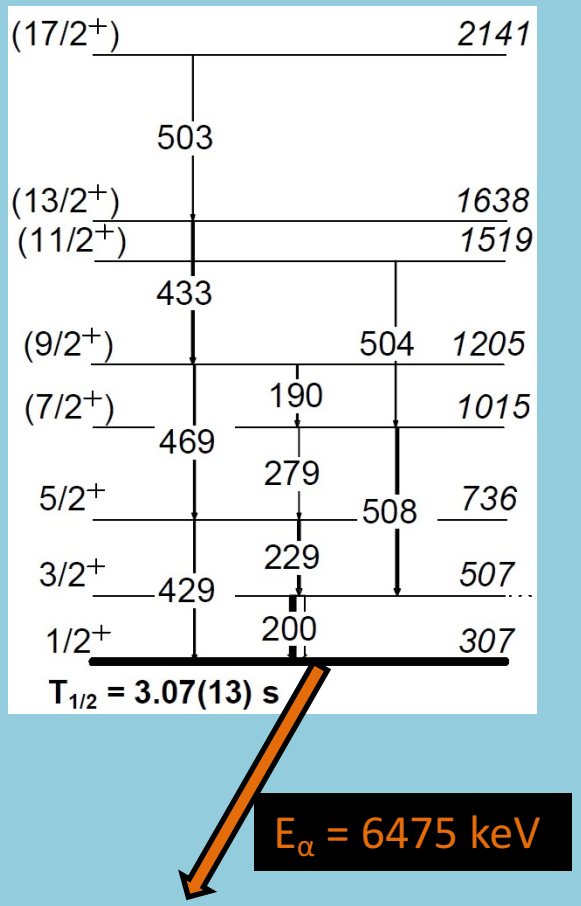


The planar spectra of delayed γ rays gated on the transitions from below the 29/2$^-$ isomeric state measured in FP clover detectors within 5 μs in ^{195}Bi.

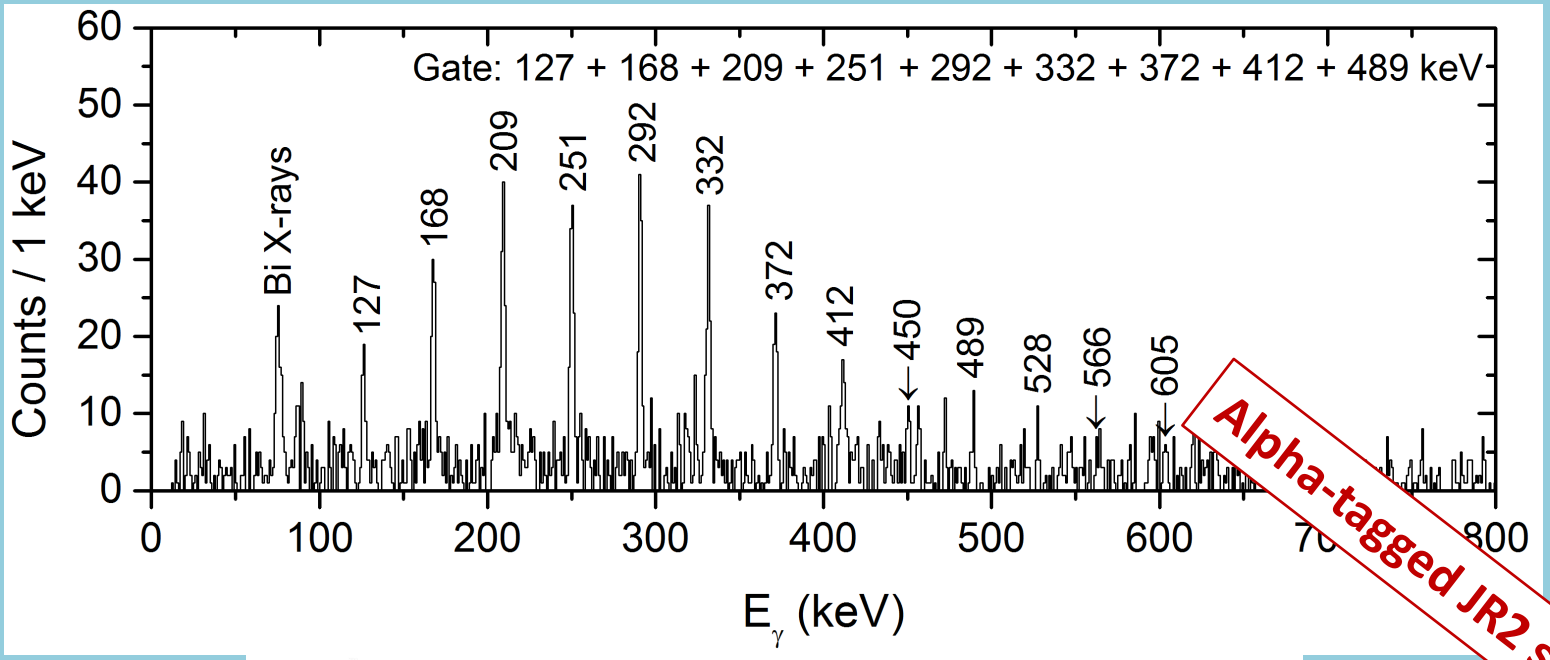
½⁺ proton intruder state in ^{193}Bi

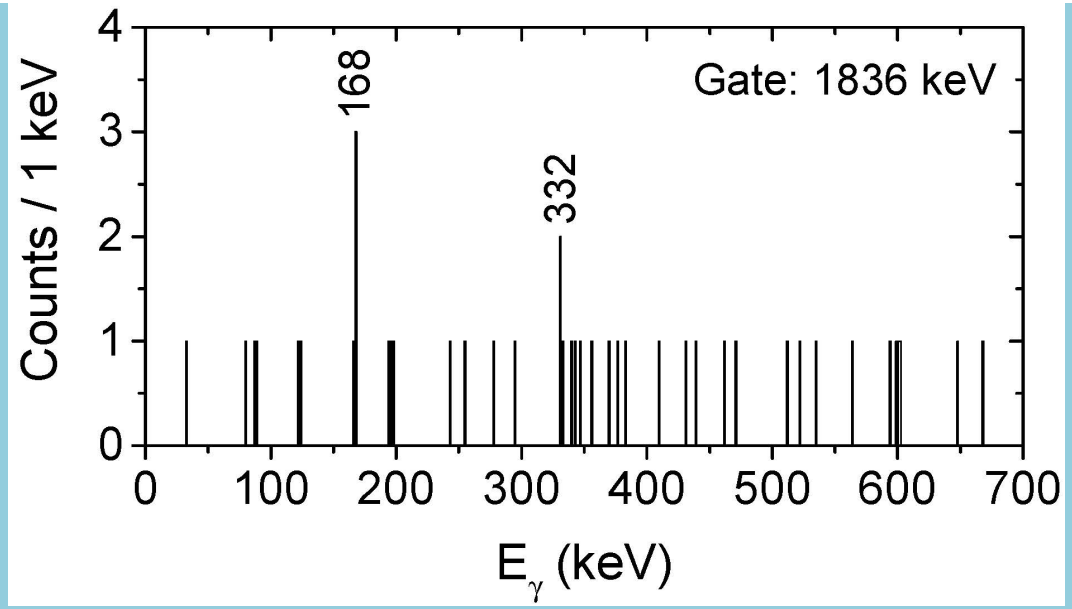
- The half-life remeasured → $T_{1/2}$ = 3.07(13) s
- RDT technique as a tool for establishing the structure built on top of this state.
- Understanding of the band structure not very clear – several possible explanations (excitations across the shell gap; shape-change within the band)





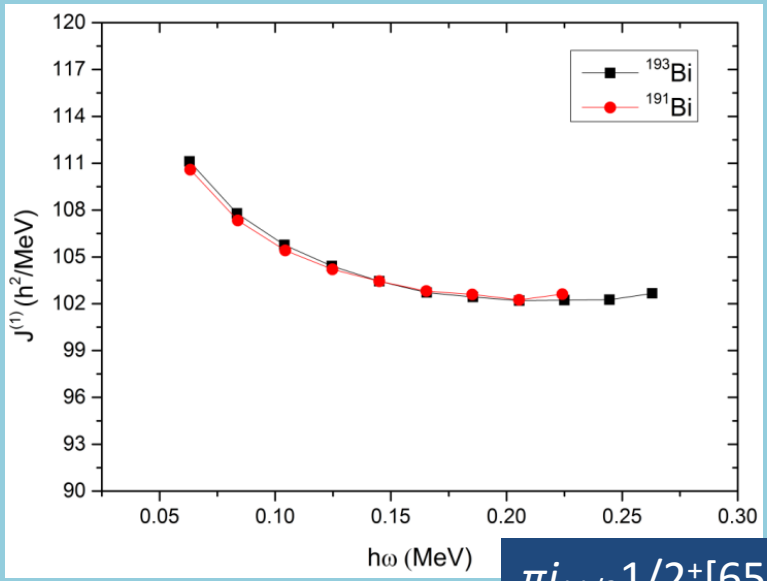
Superdeformation

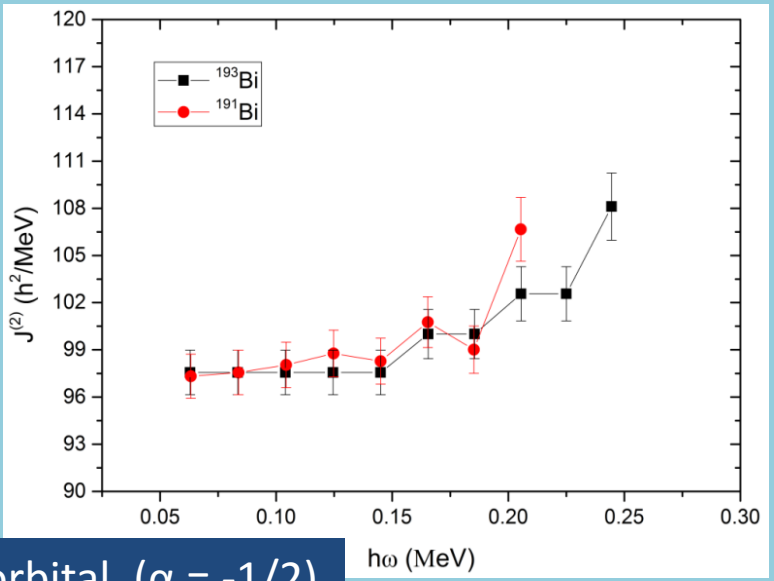




Alpha-tagged JR2 spectra

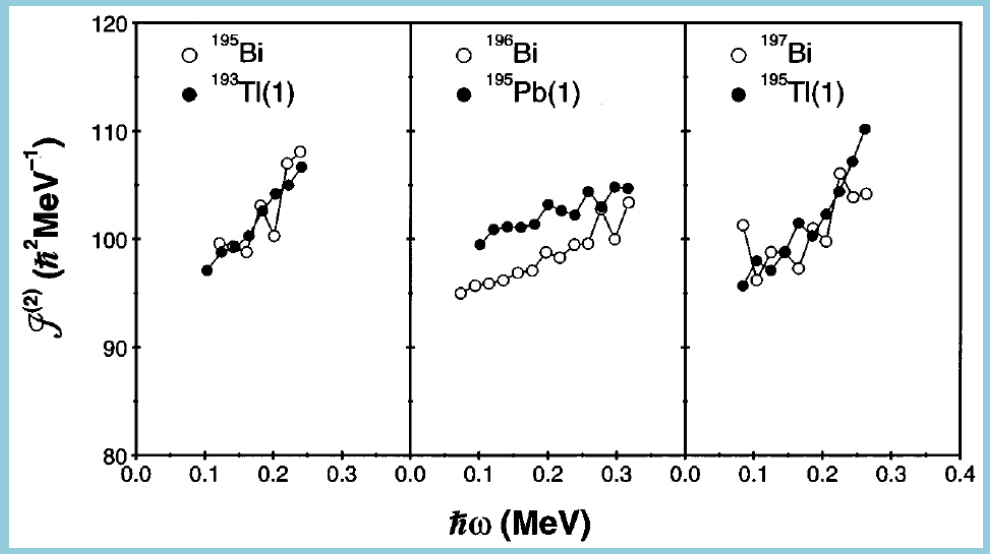
„Identical“ SD bands



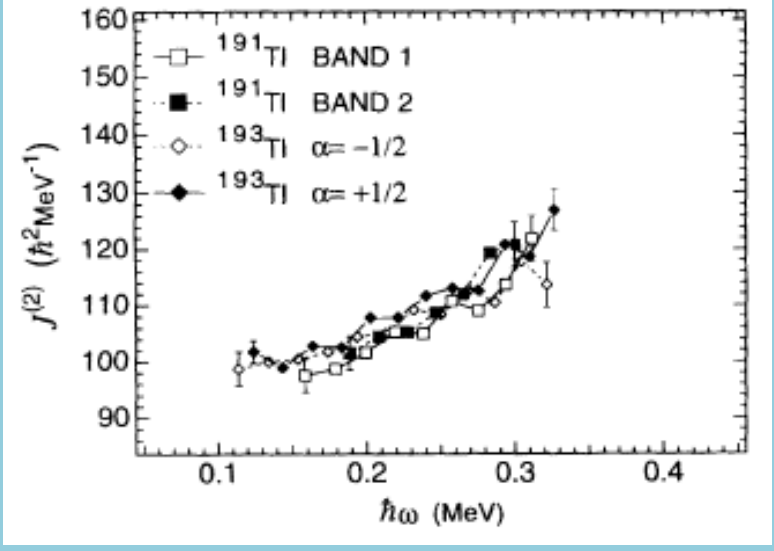


$\pi i_{11/2}1/2^+[651]$ orbital, (α = -1/2)

W. Nazarewicz, R. Wyss, and A. Johnson, Nucl. Phys. **A 503**, 285 (1989)
W. Satula *et al.*, Nucl. Phys. **A 529**, 289 (1991)



R. M. Clark *et al.*, PR **C** Vol. **53**, No. **1**, (1996)

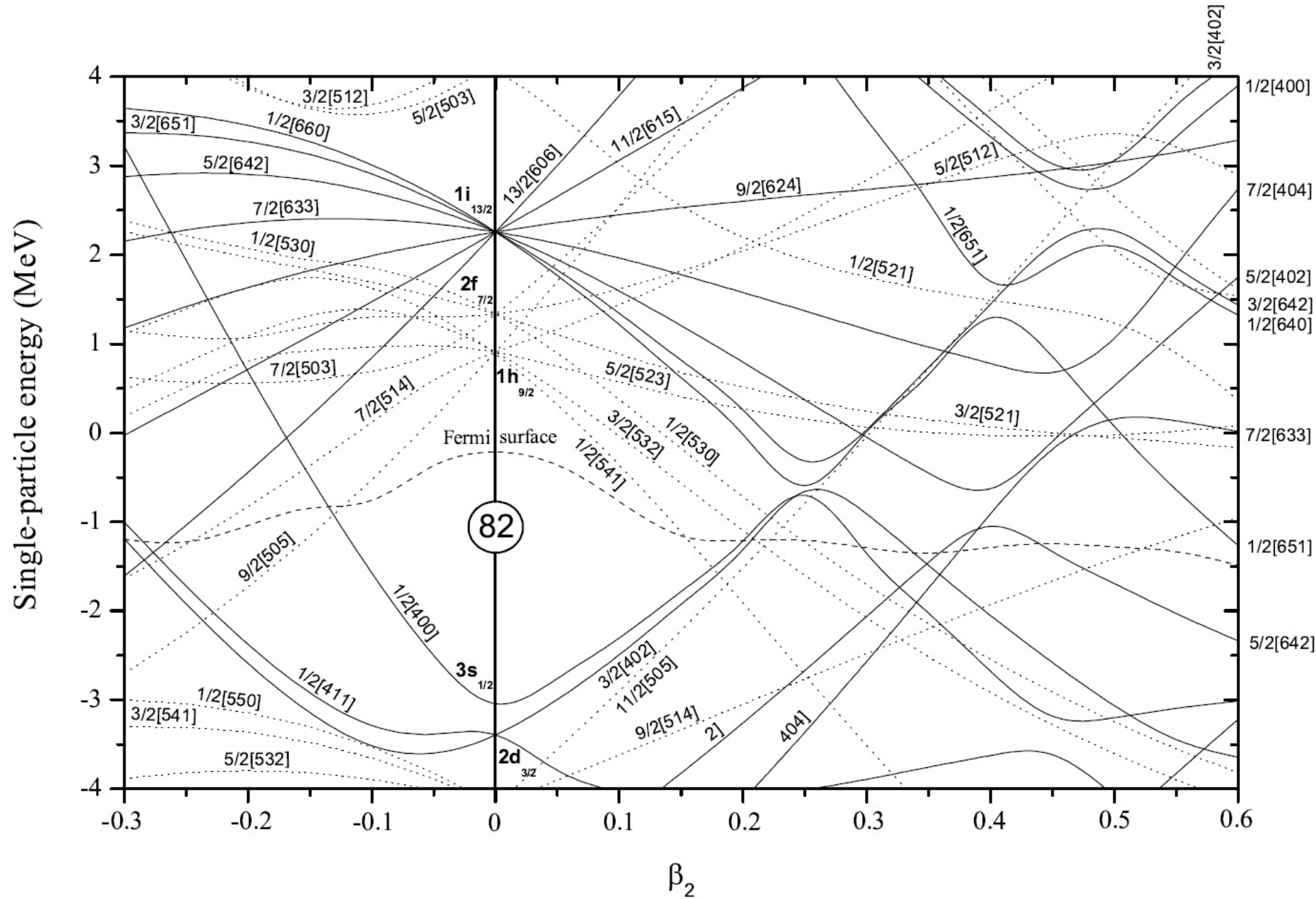


S. Pilotte *et al.*, PR **C** Vol. **49**, No. **2**, (1994)

Summary

- Extensive level schemes for both Bi isotopes
- Onset of collectivity also present in ^{195}Bi
- Evidence proving the smaller quadrupole deformations in ^{195}Bi than in ^{193}Bi
- New high-spin isomeric states found in both odd-A Bi isotopes
- Superdeformed band identified in ^{193}Bi
- New configurations explained mainly on the basis of particle-core coupling scheme

Thank You for Your attention!


Single-particle energy (MeV)
β2
Fermi surface
82
1i 13/2
2f 7/2
1h 9/2
3s 1/2
2d 3/2
3/2[512]
5/2[503]
3/2[651]
1/2[660]
5/2[642]
7/2[633]
1/2[530]
7/2[503]
7/2[514]
9/2[505]
1/2[400]
1/2[411]
1/2[550]
3/2[541]
5/2[532]
13/2[606]
11/2[615]
9/2[624]
5/2[512]
1/2[651]
1/2[521]
5/2[523]
3/2[532]
1/2[530]
1/2[541]
3/2[521]
3/2[402]
11/2[505]
9/2[514]
2]
404]
3/2[402]
1/2[400]
7/2[404]
5/2[402]
3/2[642]
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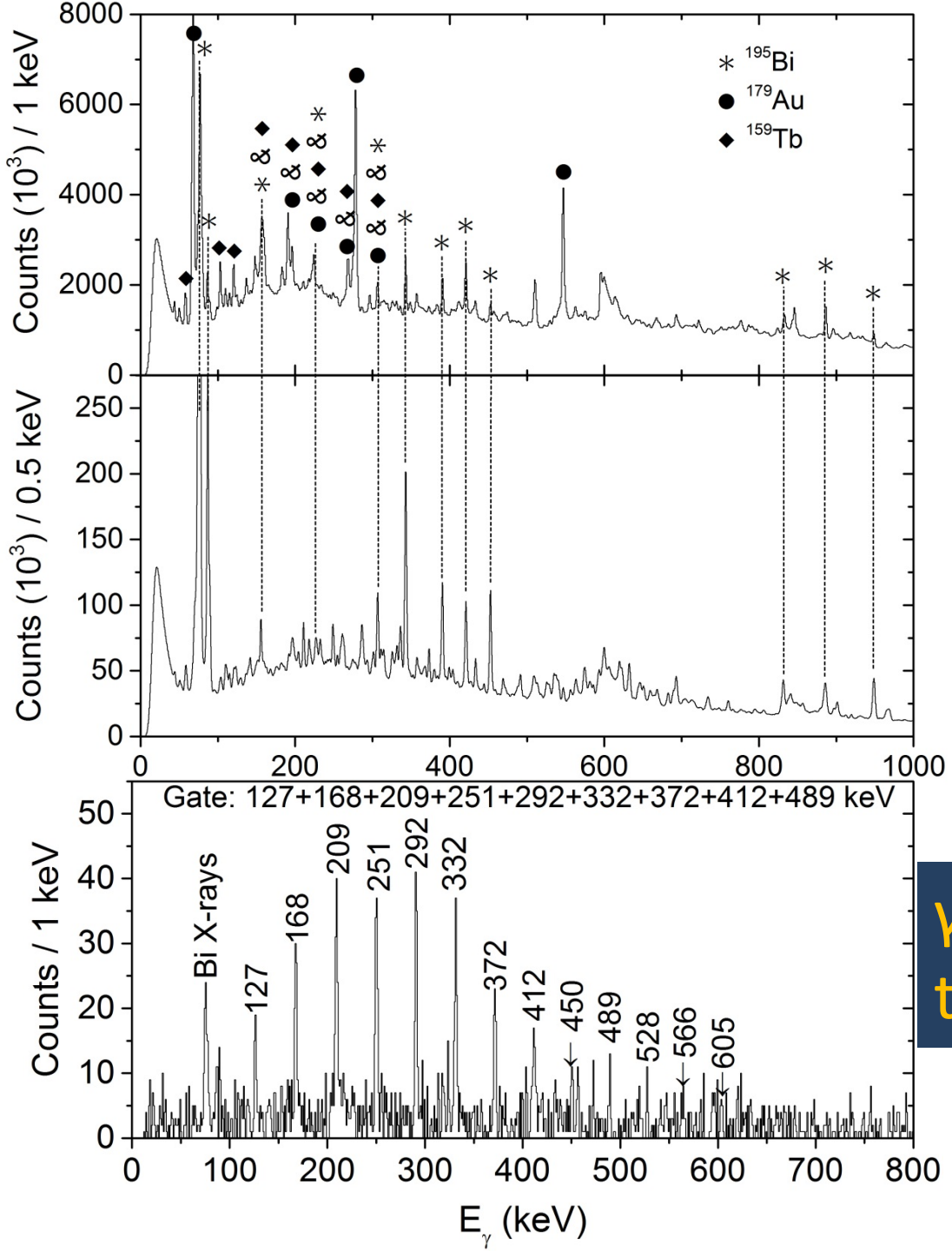
7/2[633]
1/2[651]
5/2[642]



4-fold γ-ray data

1.8 billion γ rays

Recoil-gated γ-ray data

γ-ray data tagged on the alpha decay of recoils