Nuclear Structure of Odd-Au Isotopes

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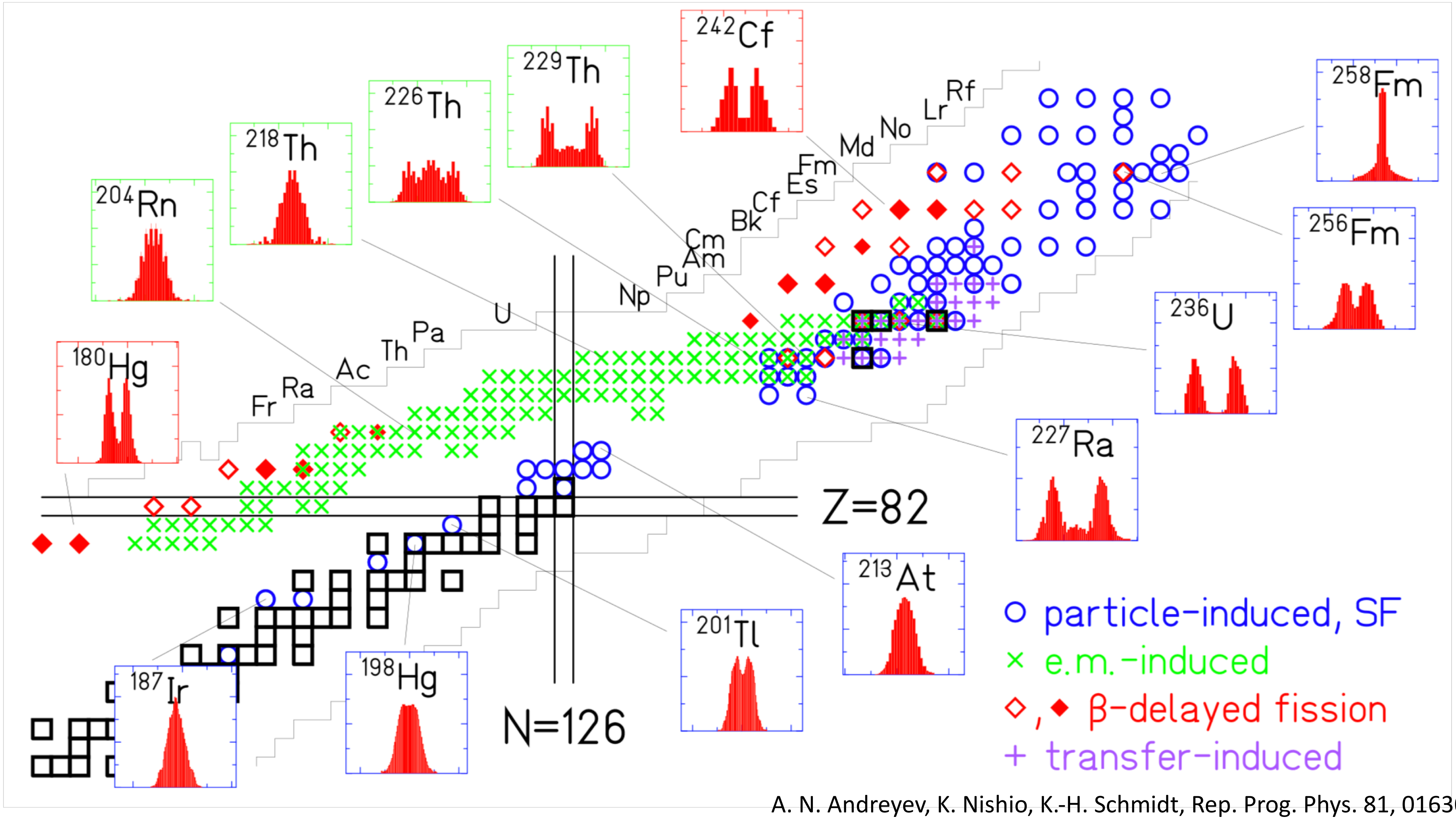
On behalf of

IS521 collaboration *(CERN-ISOLDE: Institute of Physics, University of Liverpool, iThemba Labs)*

JR115 collaboration *(University of Jyväskylä, University of Liverpool, Institute of Physics)*

Nuclear Fission and Structure of Exotic Isotopes,
Japan Atomic Energy Agency (JAEA), March 25 – 27, 2019, Tokai

Neutron-deficient Hg isotopes = region of beta-delayed fission



A. N. Andreyev, K. Nishio, K.-H. Schmidt, Rep. Prog. Phys. 81, 016301 (2018).

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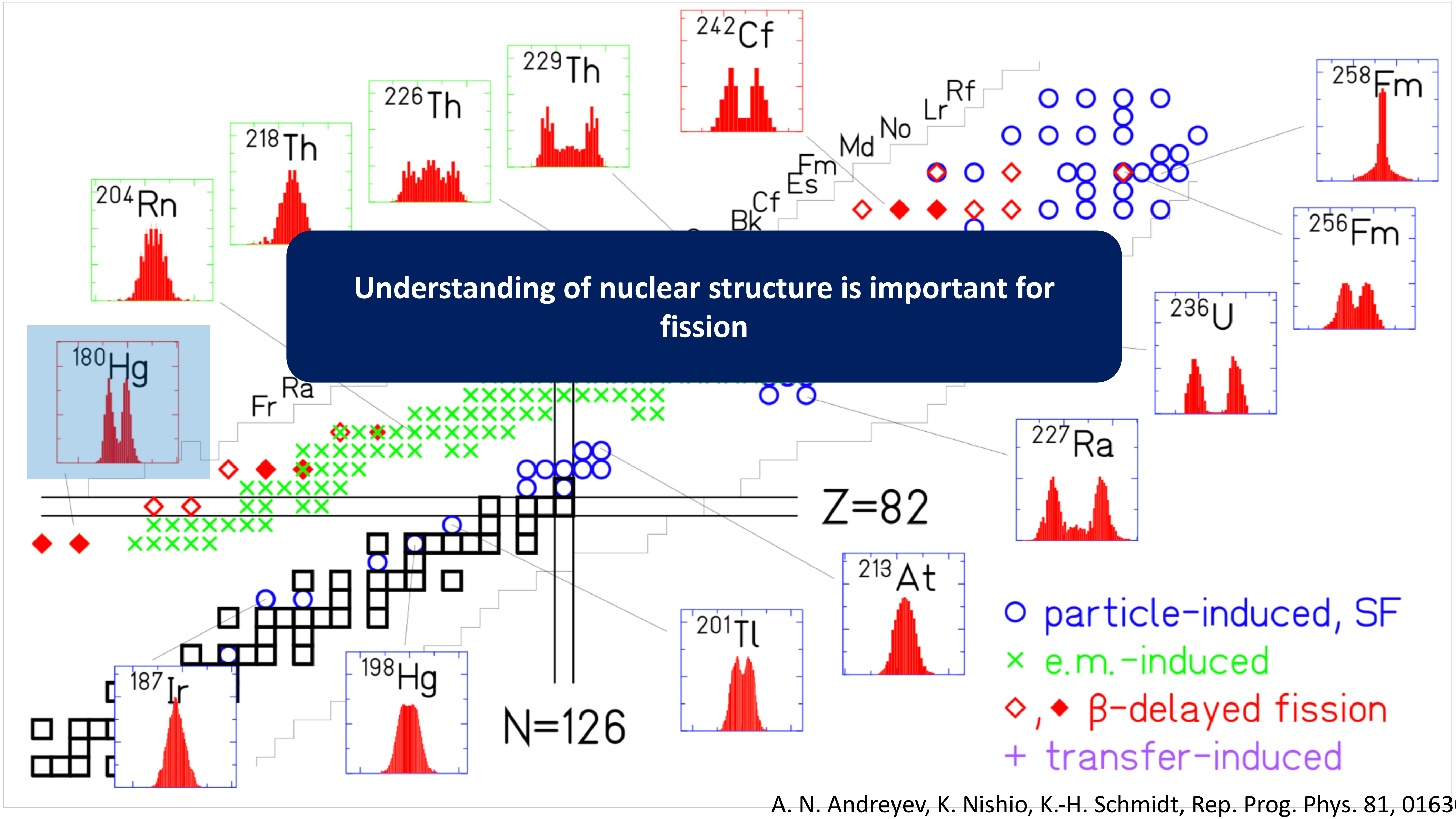


Understanding of nuclear structure is important for fission

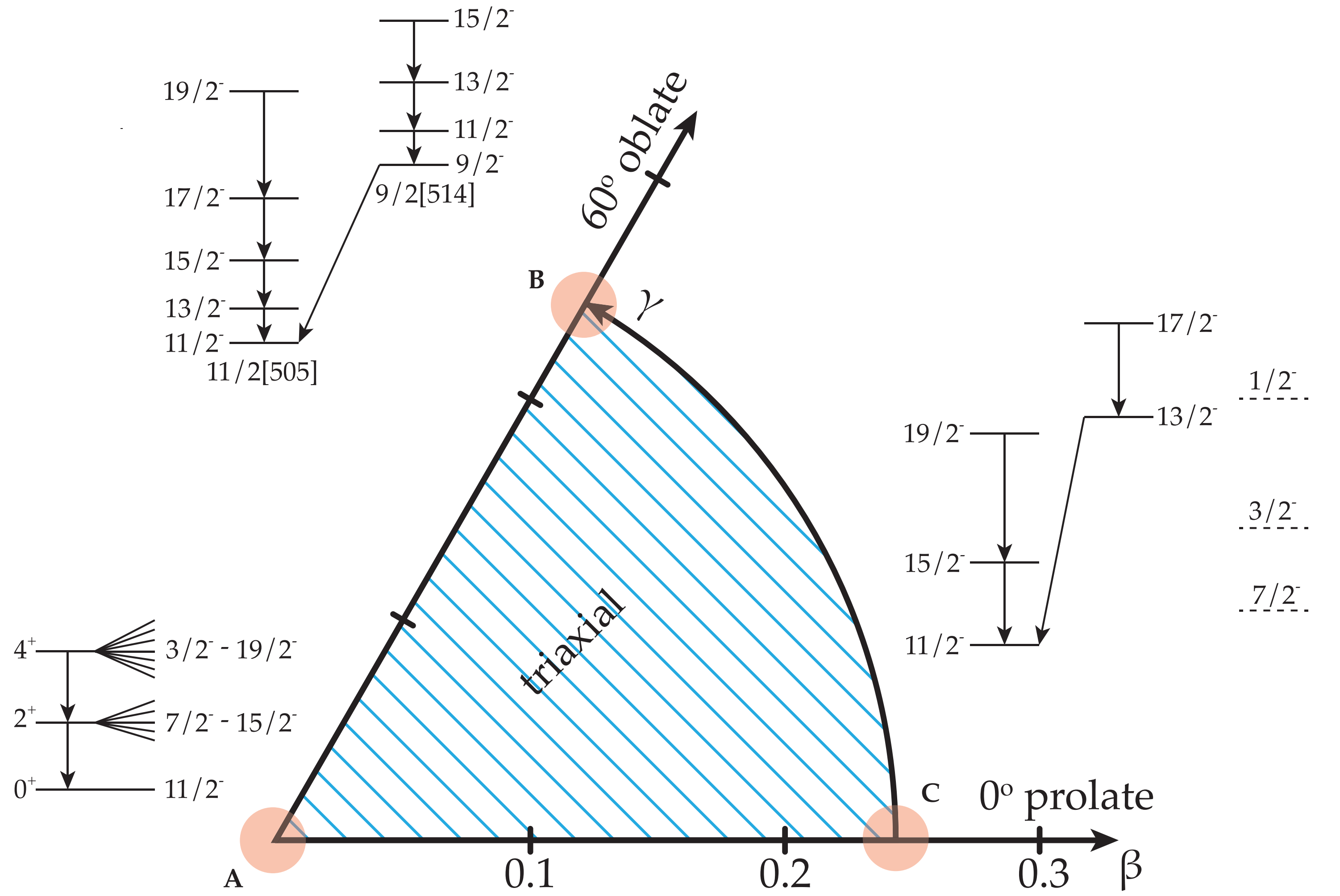
A. N. Andreyev, K. Nishio, K.-H. Schmidt, Rep. Prog. Phys. 81, 016301 (2018).

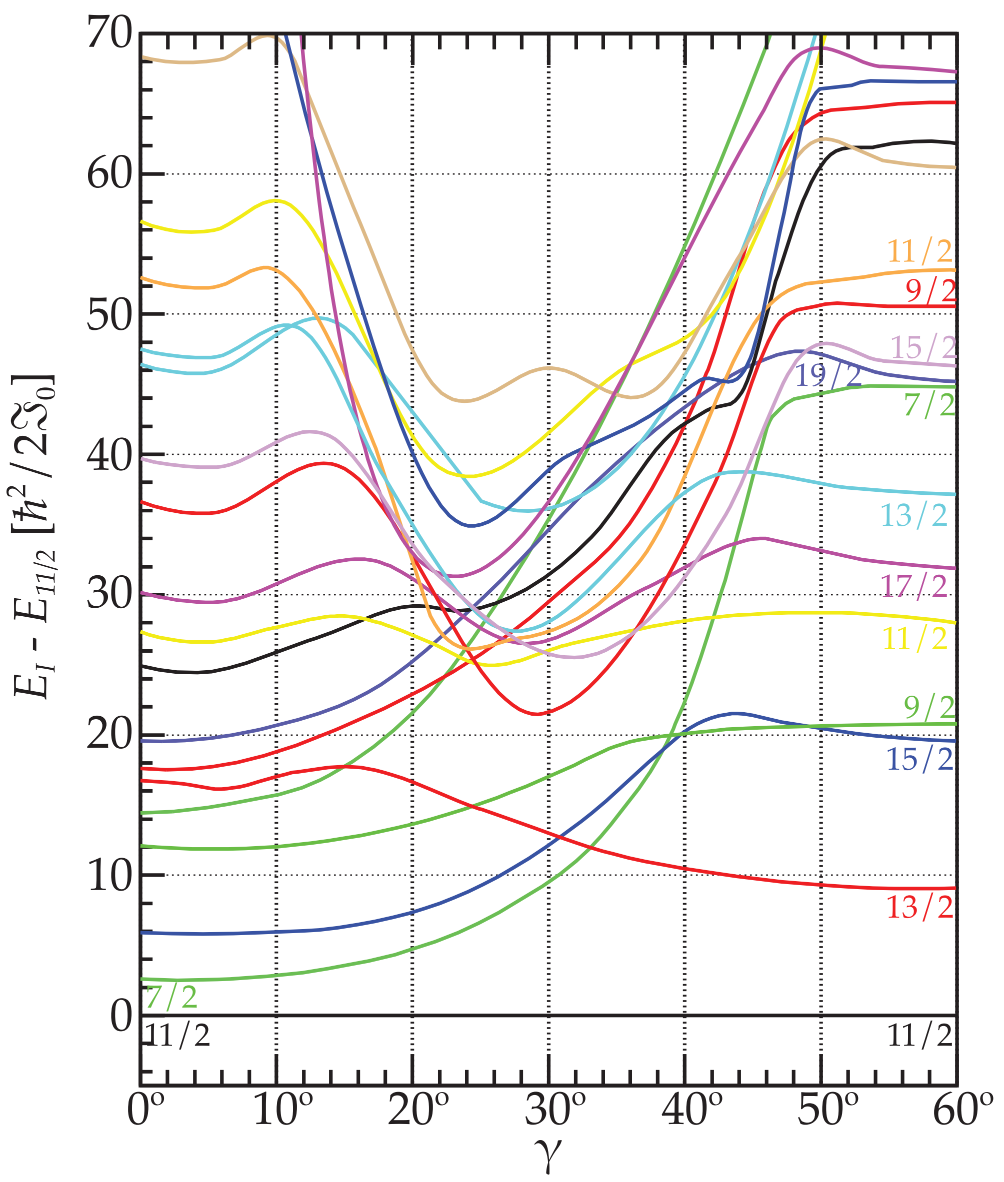
How can we use odd-Au isotopes to understand the structure of Hg?

- An odd particle acts as a probe of the core
  - Information on independent particle states
  - Information on deformation: axial and triaxial shapes
  - Information on pairing from blocking
  - Identification of intruder states free of mixing
  - Information on rotational collectivity
- Need of beta decay studies - non-yrast states
- Need of in-beam studies - rotational bands

- **One way how towards understanding even-even Hg isotopes goes through odd-Au isotopes**

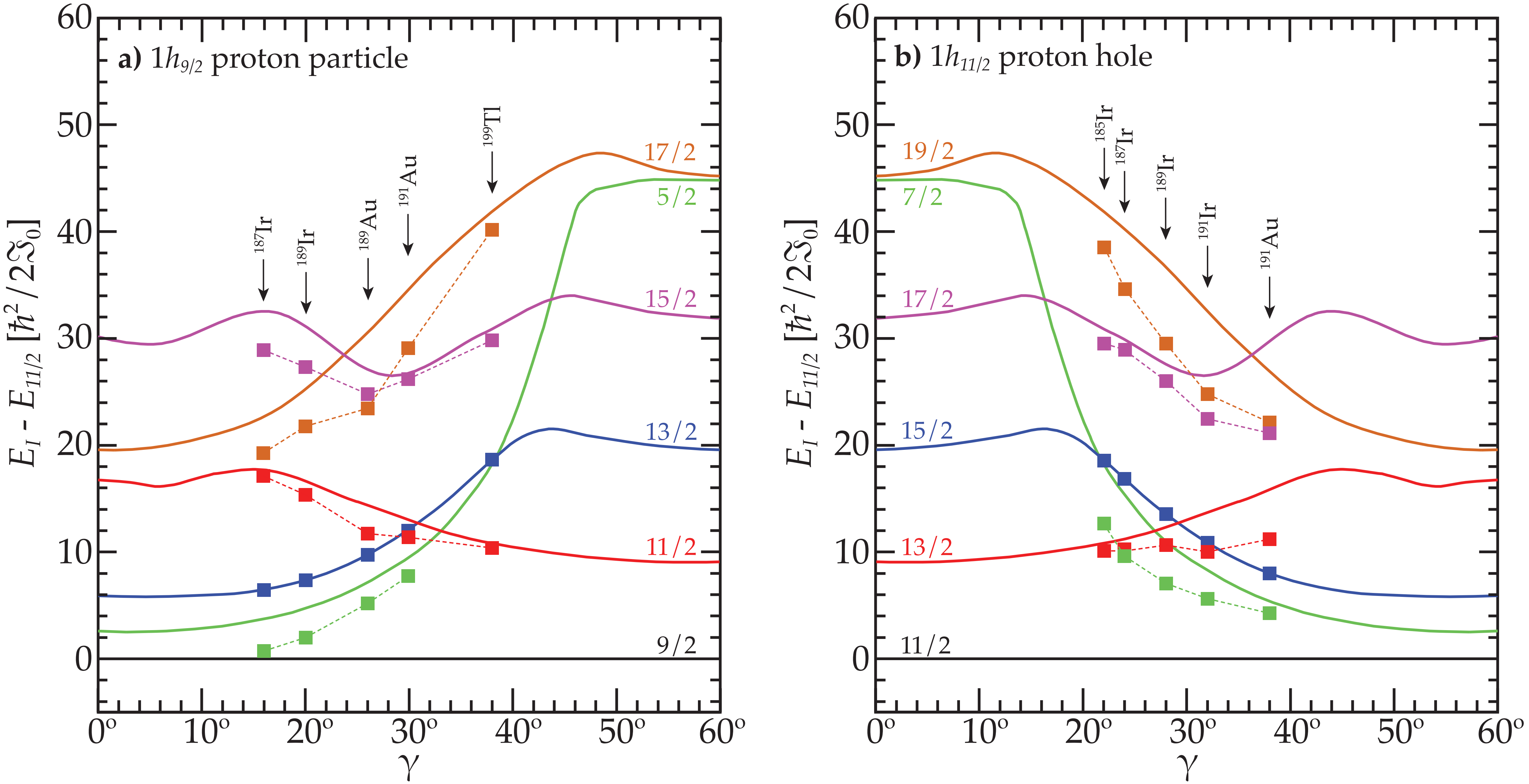
Particle-core coupling approach: Meyer-ter-Vehn model





J. Meyer-ter-Vehn *et al.*, Phys. Rev. Lett. **32**, 1383 (1974).

Meyer-ter-Vehn model: comparison with the data



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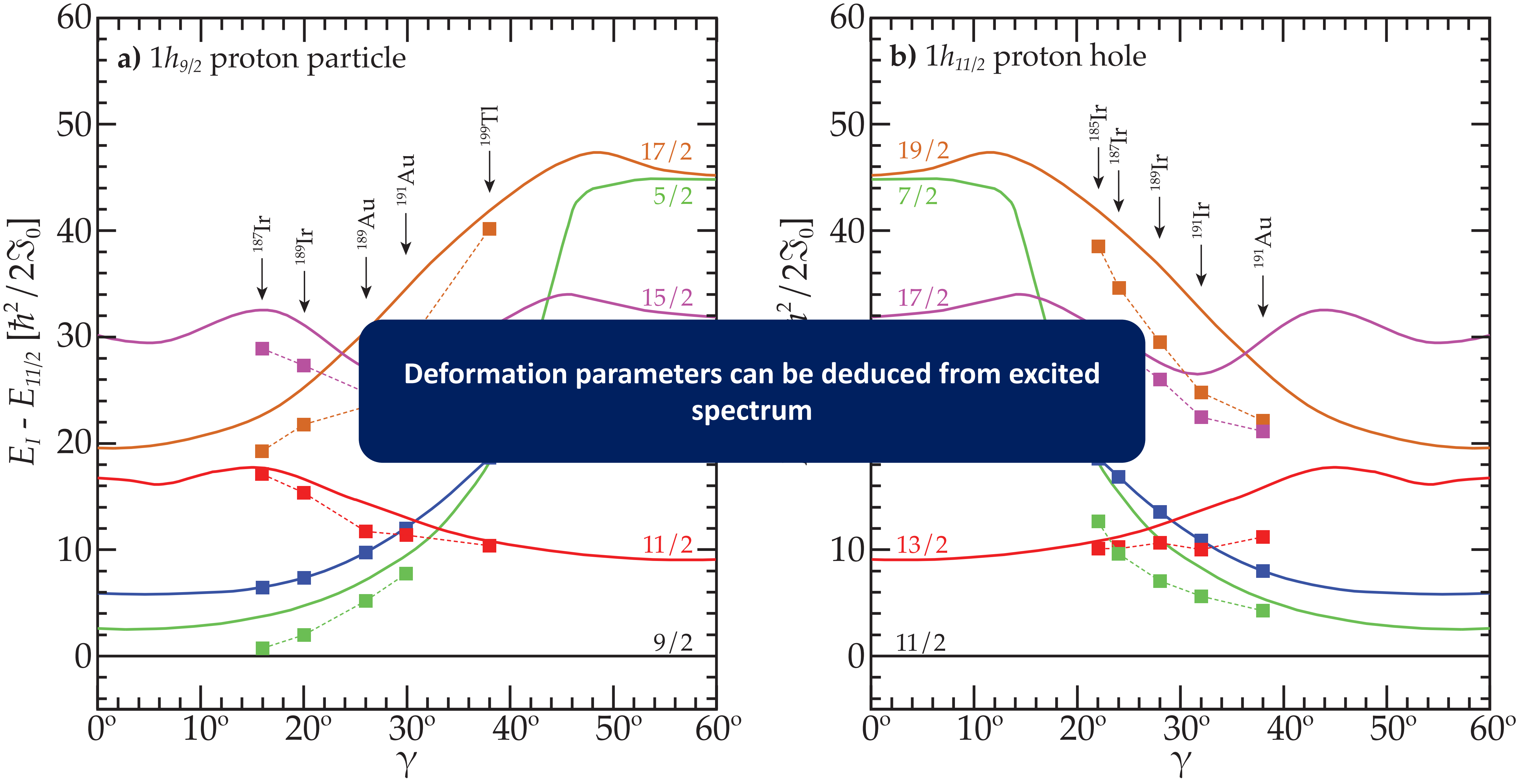
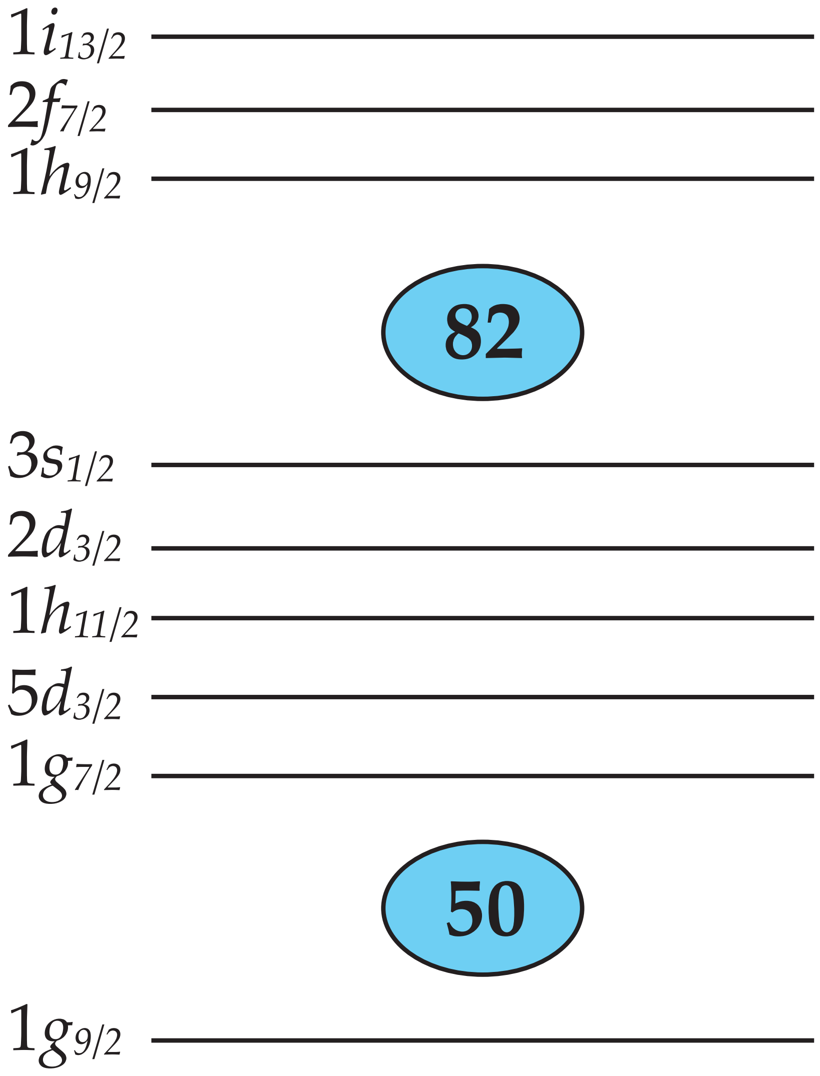


Deformation parameters can be deduced from excited spectrum

Which orbitals are involved in odd-Au isotopes?



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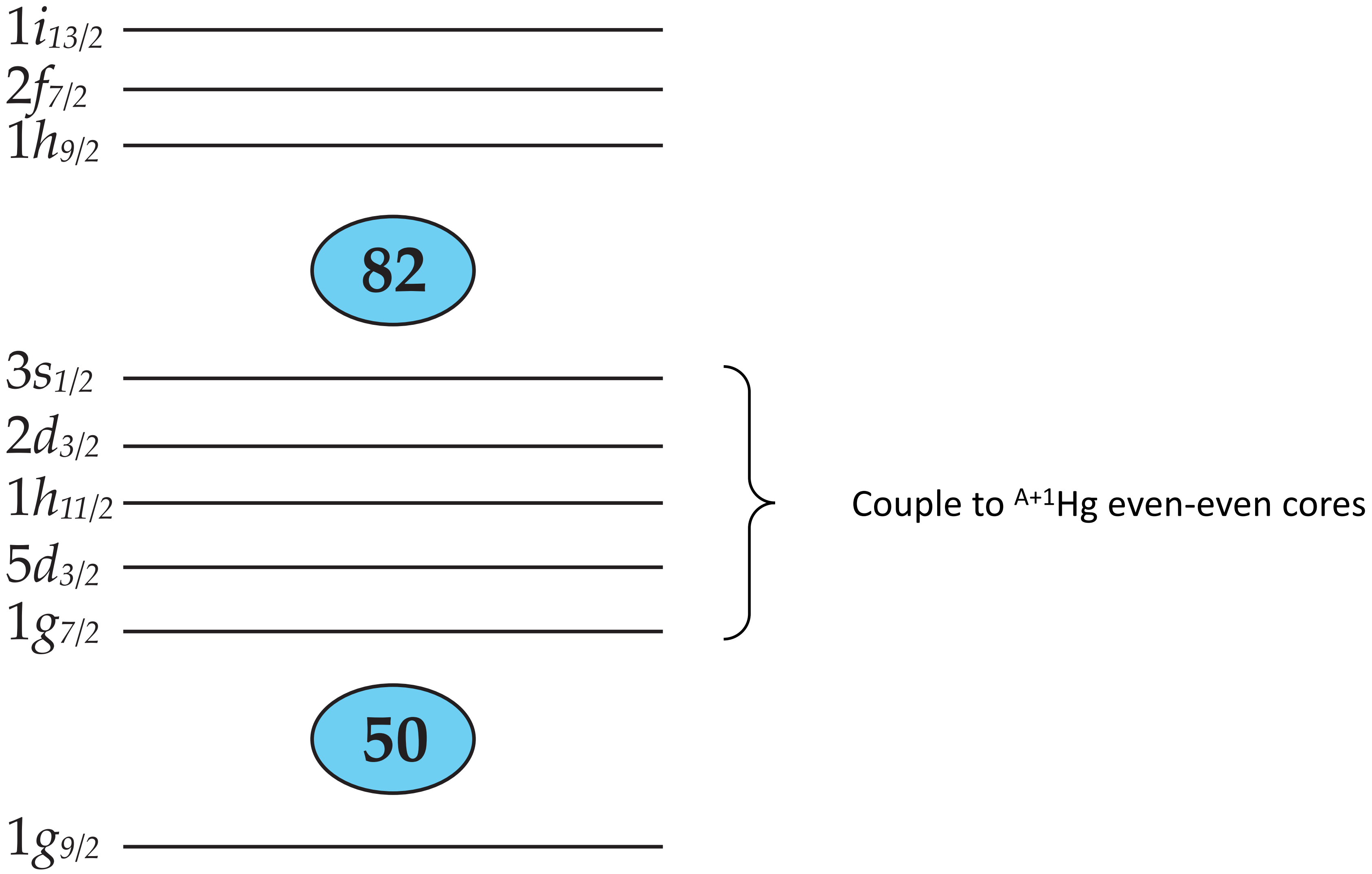

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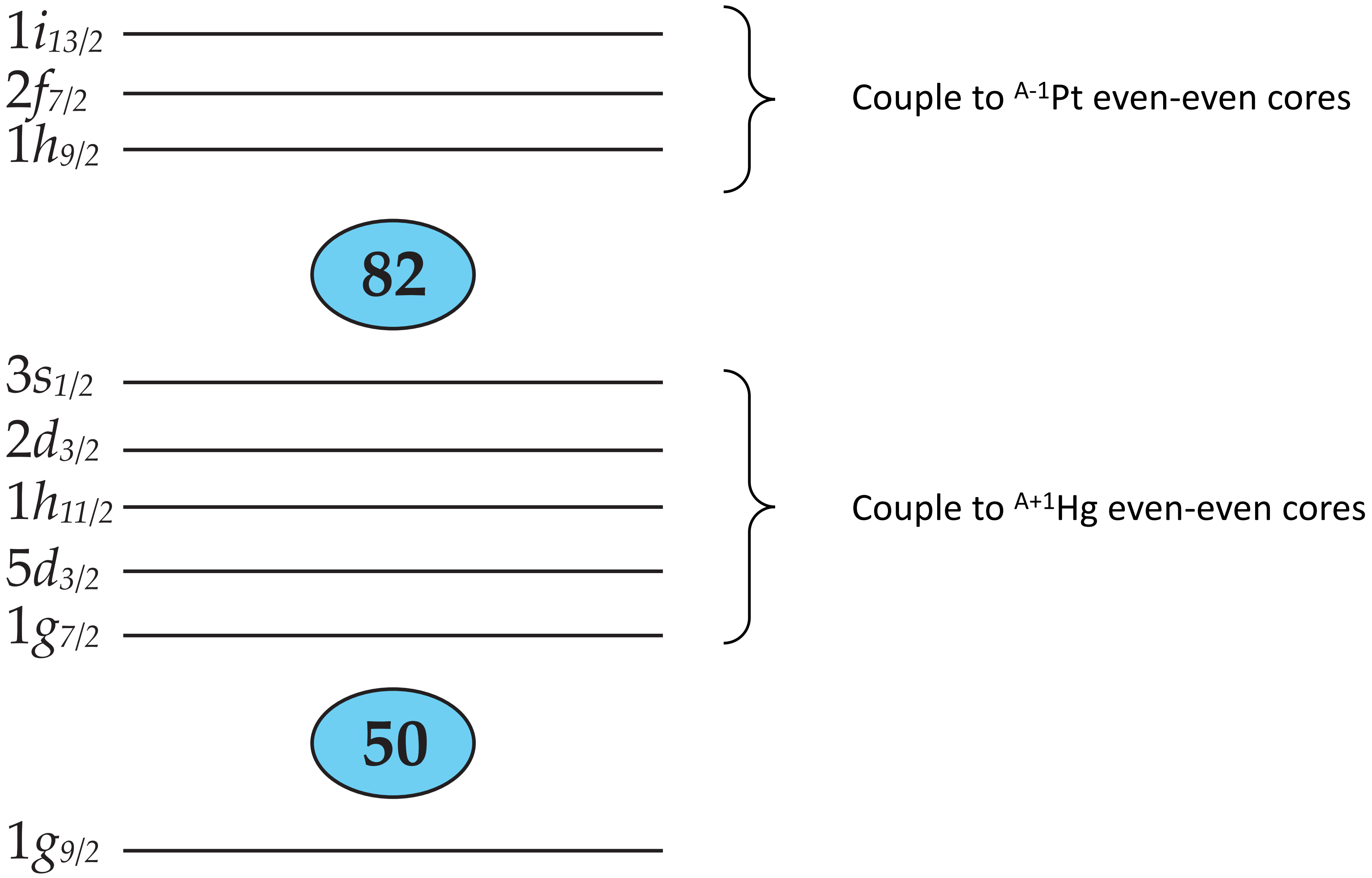
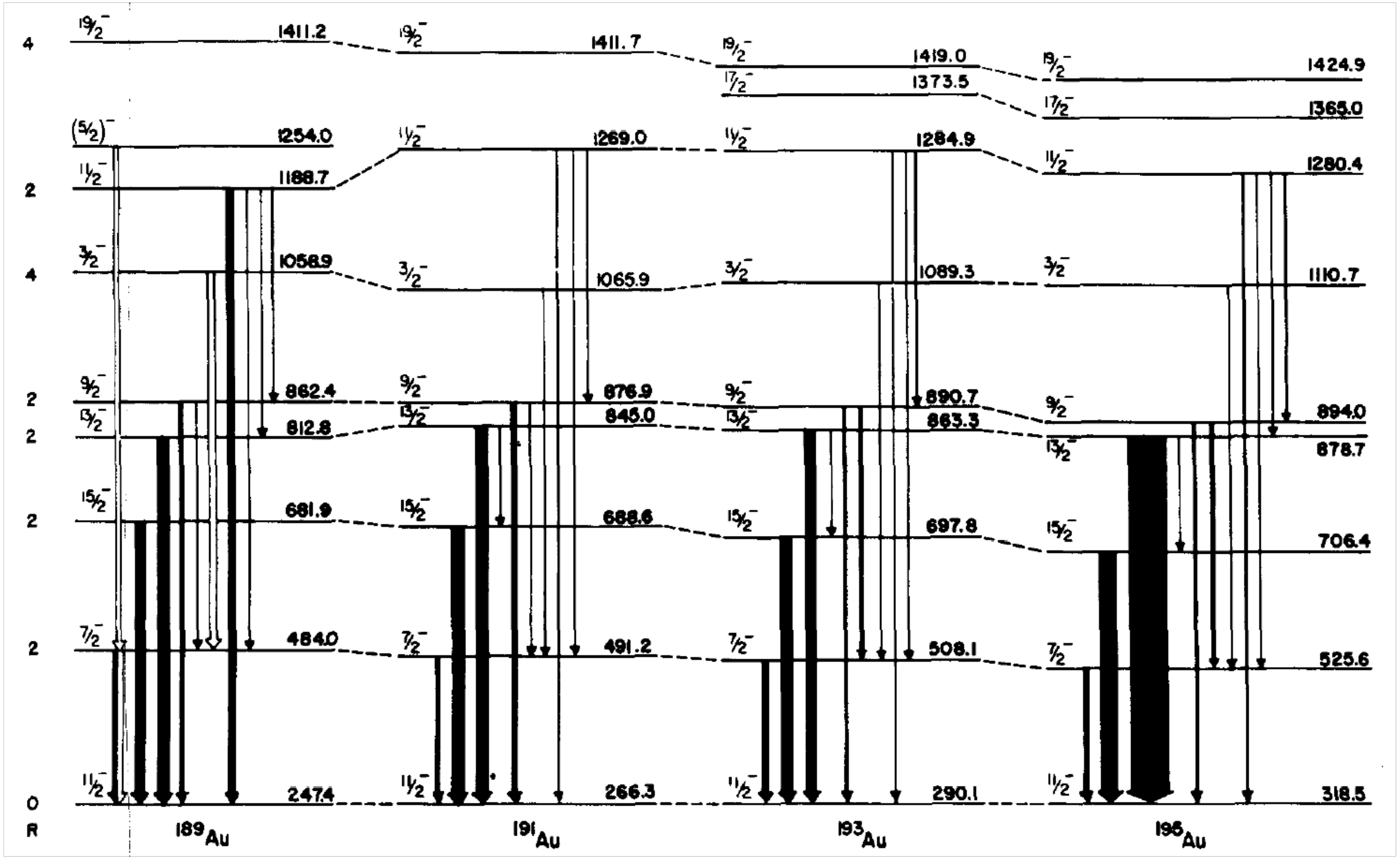
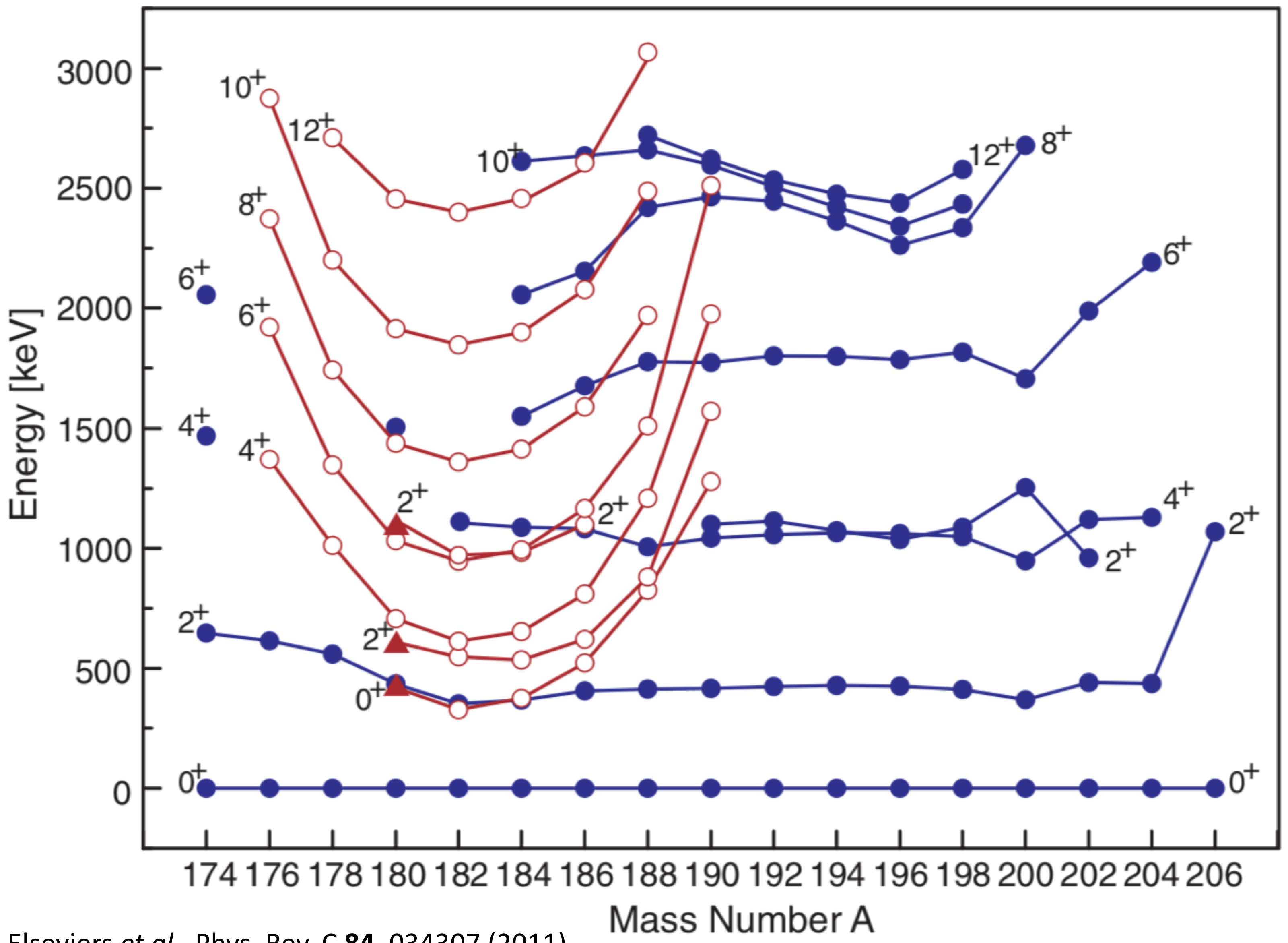


Roadmap to odd-Au isotopes: negative-parity structures



E. F. Zganjar *et al.*, Phys. Lett. **58B**, 159 (1975).

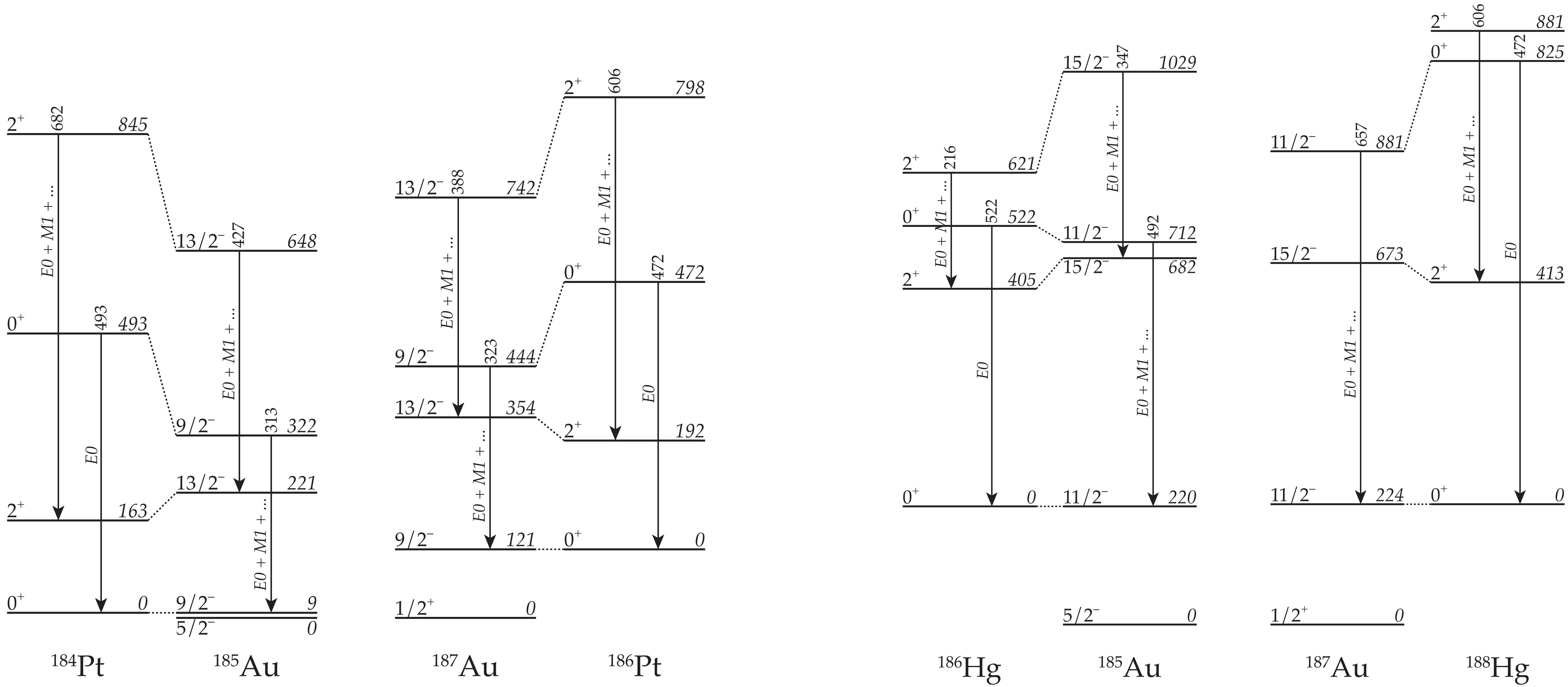
Shape coexistence in even-even Hg isotopes



J. Elseviers *et al.*, Phys. Rev. C **84**, 034307 (2011).

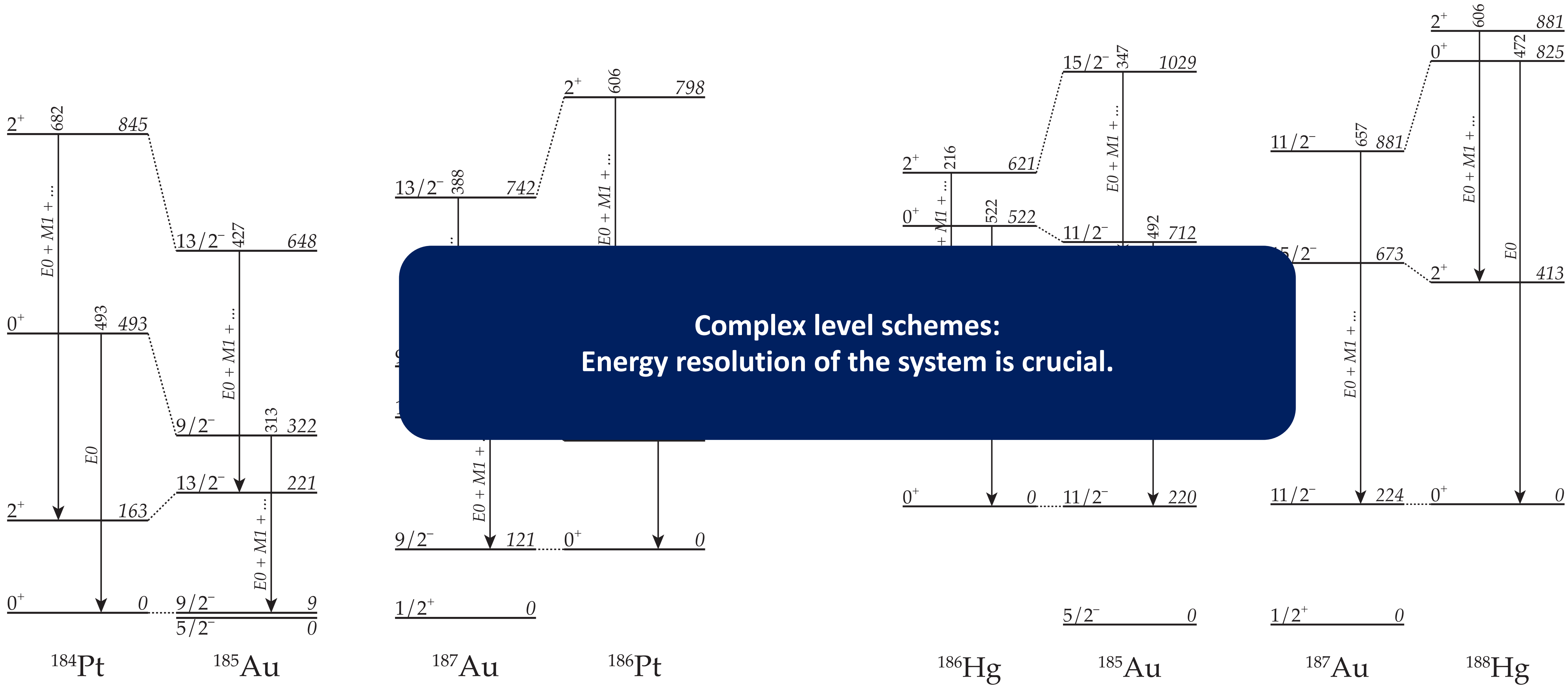
- Deformed configuration reaches the minimum close to N = 104 (midshell point)
- Similar picture exists also for even-Pt isotopes
- Therefore four types of excitations should occur in odd-Au isotopes close to midshell point
- Distinct groups of states are expected
- Electric monopole transitions occur

Shape coexistence in even-even cores



C. D. Papanicolopoulos *et al.*, Z. Phys. A **330**, 371 (1988).

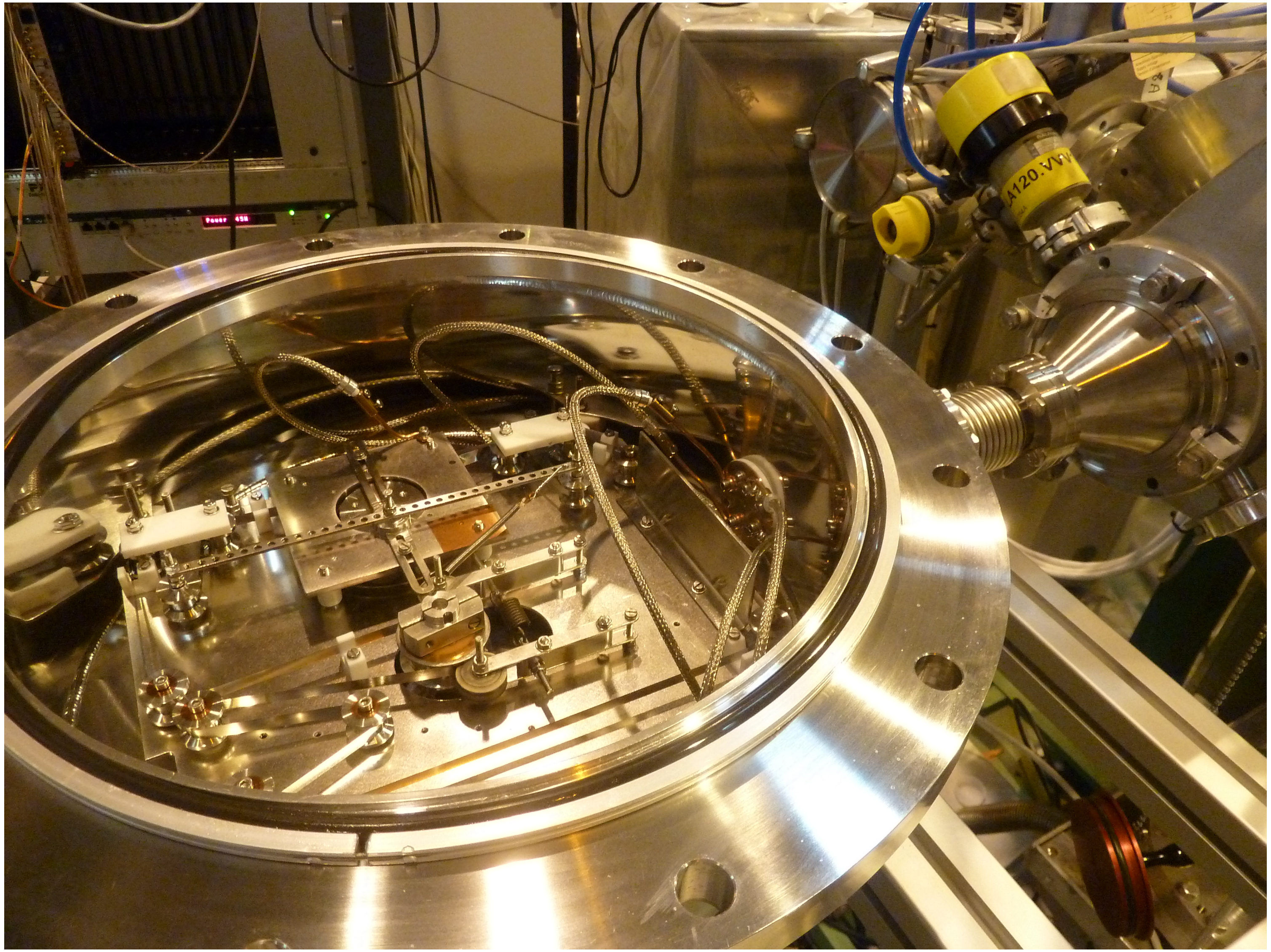
Shape coexistence in even-even cores



Complex level schemes:
Energy resolution of the system is crucial.

C. D. Papanicolopoulos *et al.*, Z. Phys. A **330**, 371 (1988).

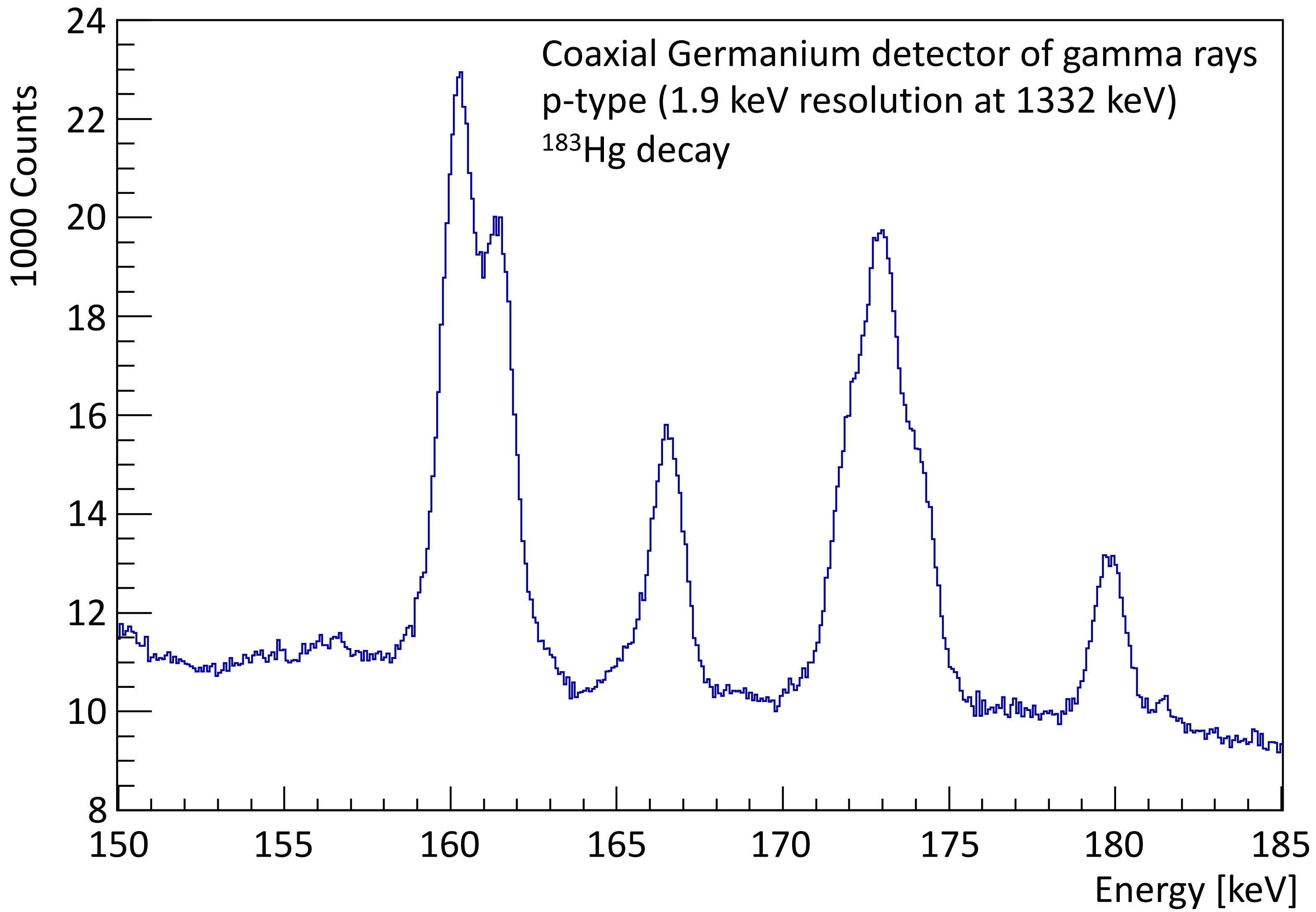
Experiment IS521 at CERN-ISOLDE: TATRA system



V. Matoušek *et al.*, Nucl. Instrum. And Meth A **812**, 118 (2016).

- **TA**pe **TRA**nsportation system inspired by 8-track tapes
- Rapidly quenched material: metallic glass is used to transport radioactive samples (deposition of ISOLDE beam)
- Operated at 3 x 10^{-8} mbar
- Windowless LN_2 cooled detector was used
- Very good resolution for conversion electrons
- Broad Energy Germanium detector (first-time used for nuclear structure)

^{183}Hg decay spectrum



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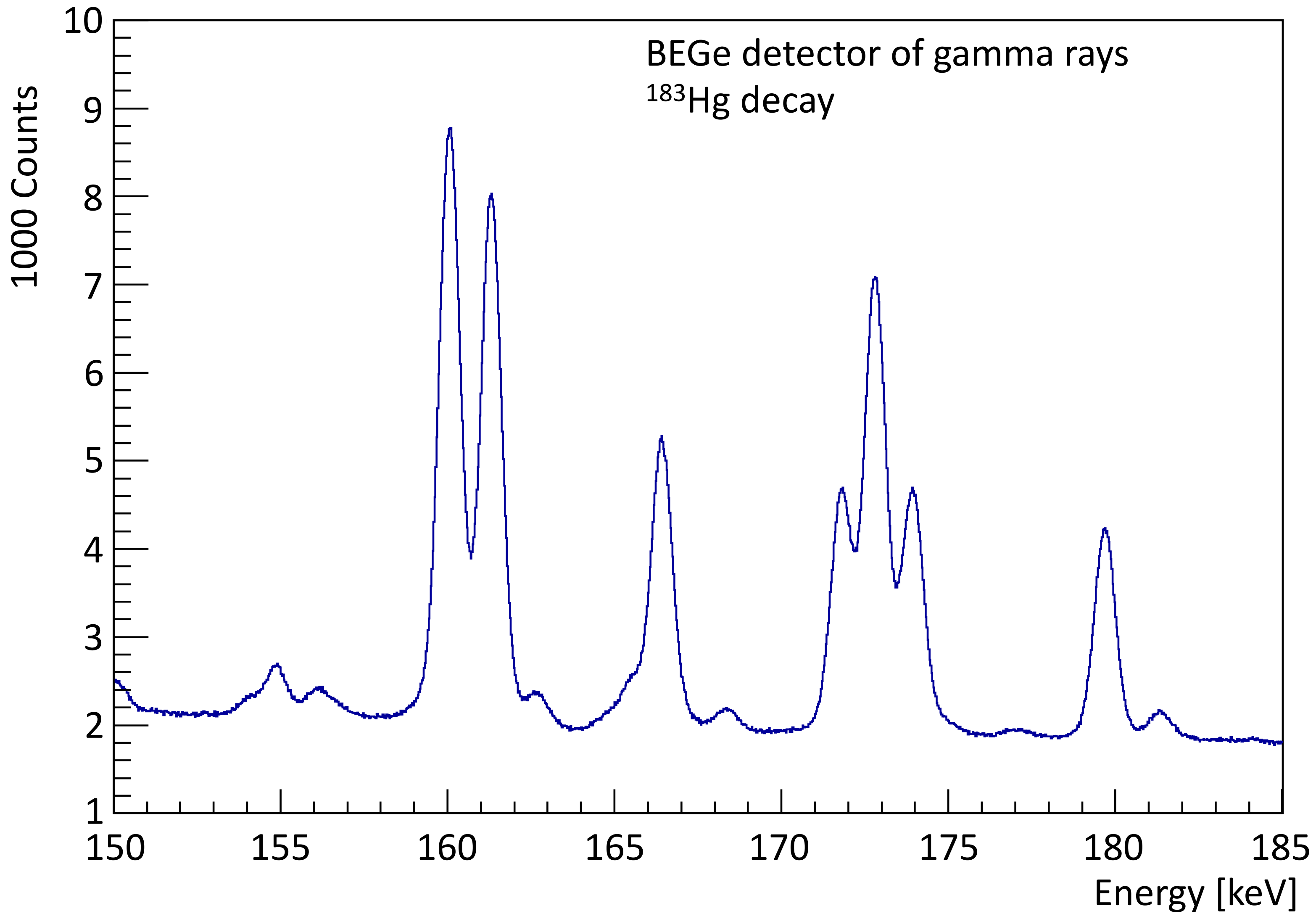
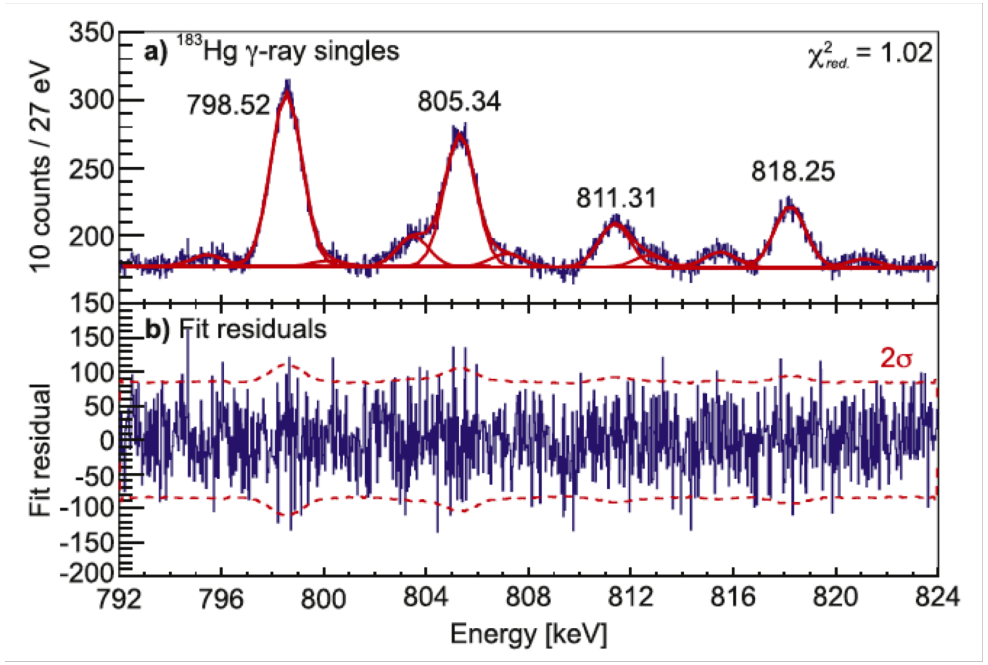
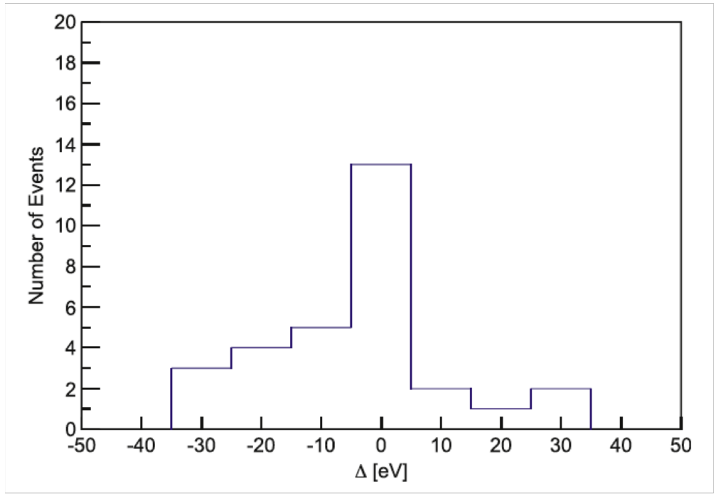


Level scheme construction with BEGe detector

- Instrumentation: Pixie-16 DAQ
- Corresponds to 32768 channels ADC
- Apporximately 1 MeV range for the BEGe, i.e. 27 eV per channel
- (Almost) ideal gaussian peak shape
- (Almost) linear background
- Rydberg-Ritz combination principle to 30 eV precision
- System is combined with “standard“ germanium detectors for coincidences





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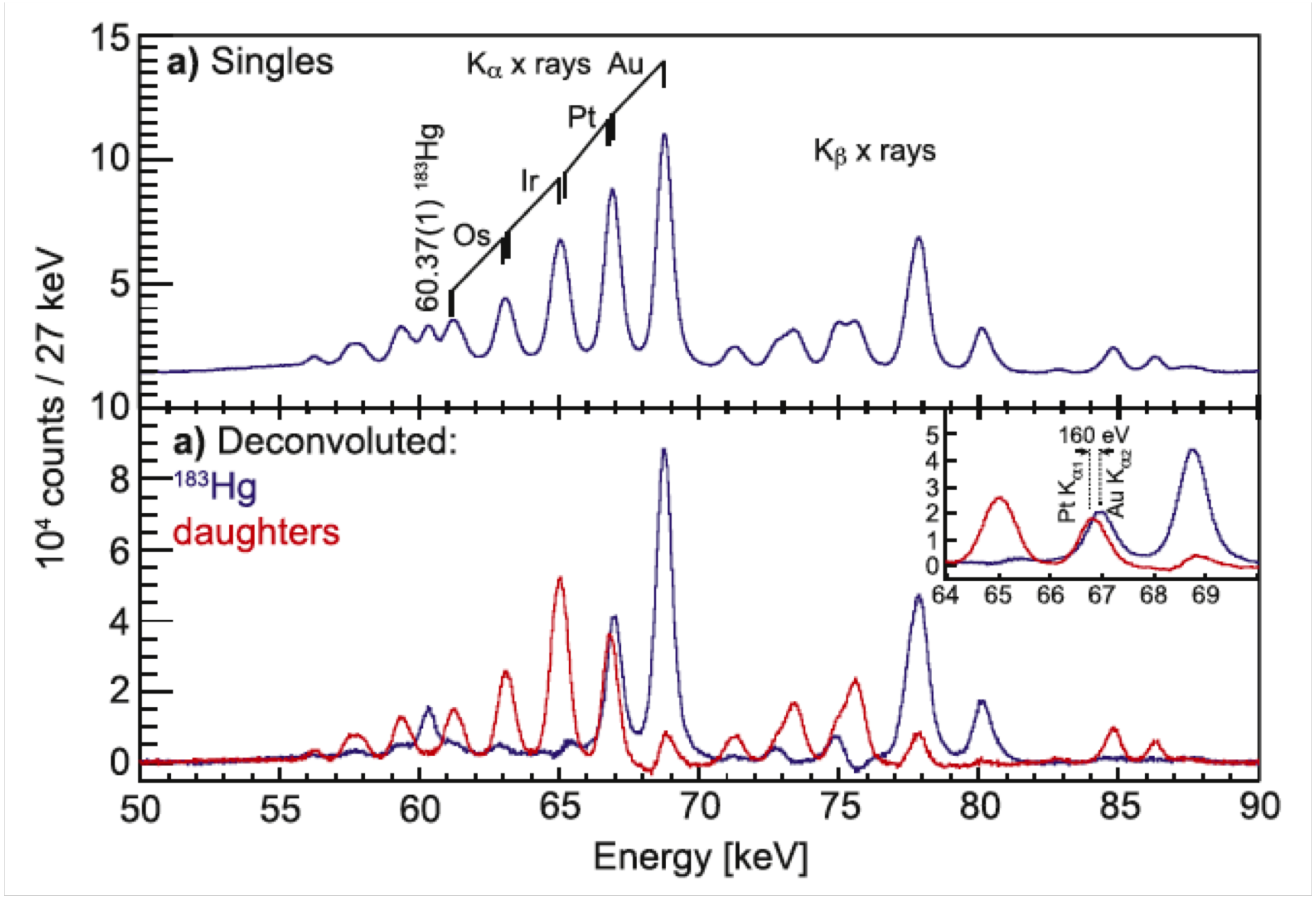
Subtraction of daughter activities using time structure of the data



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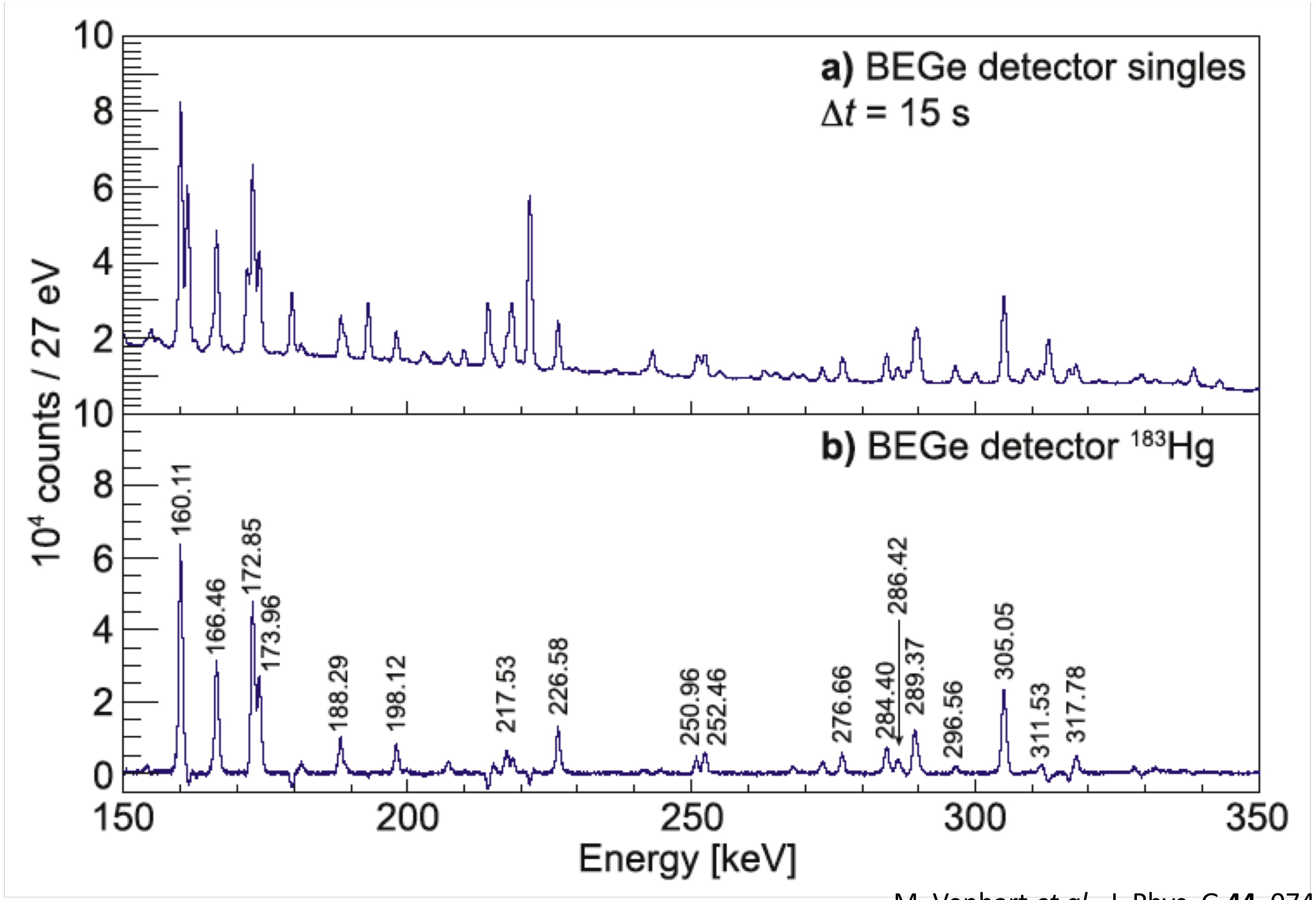
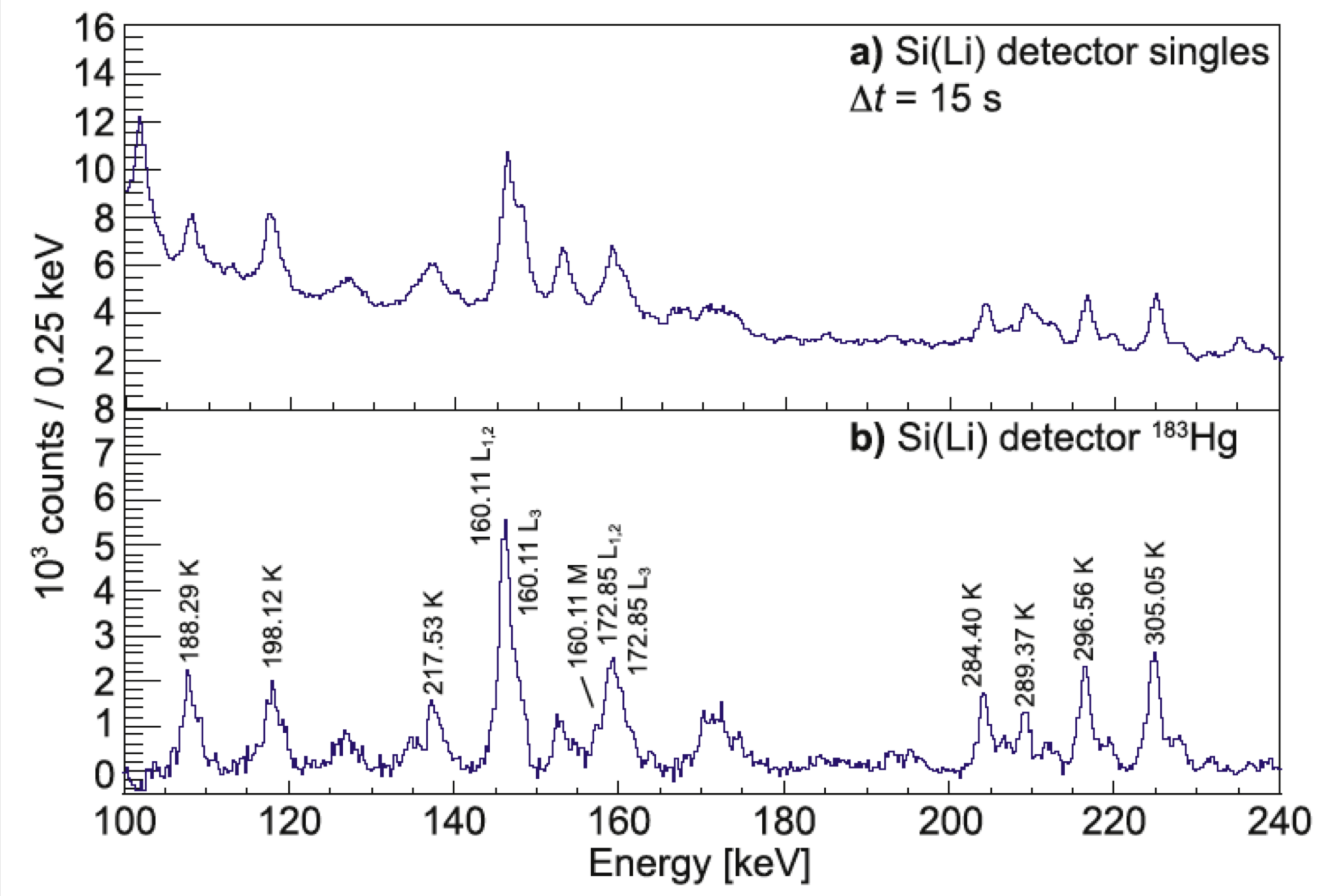


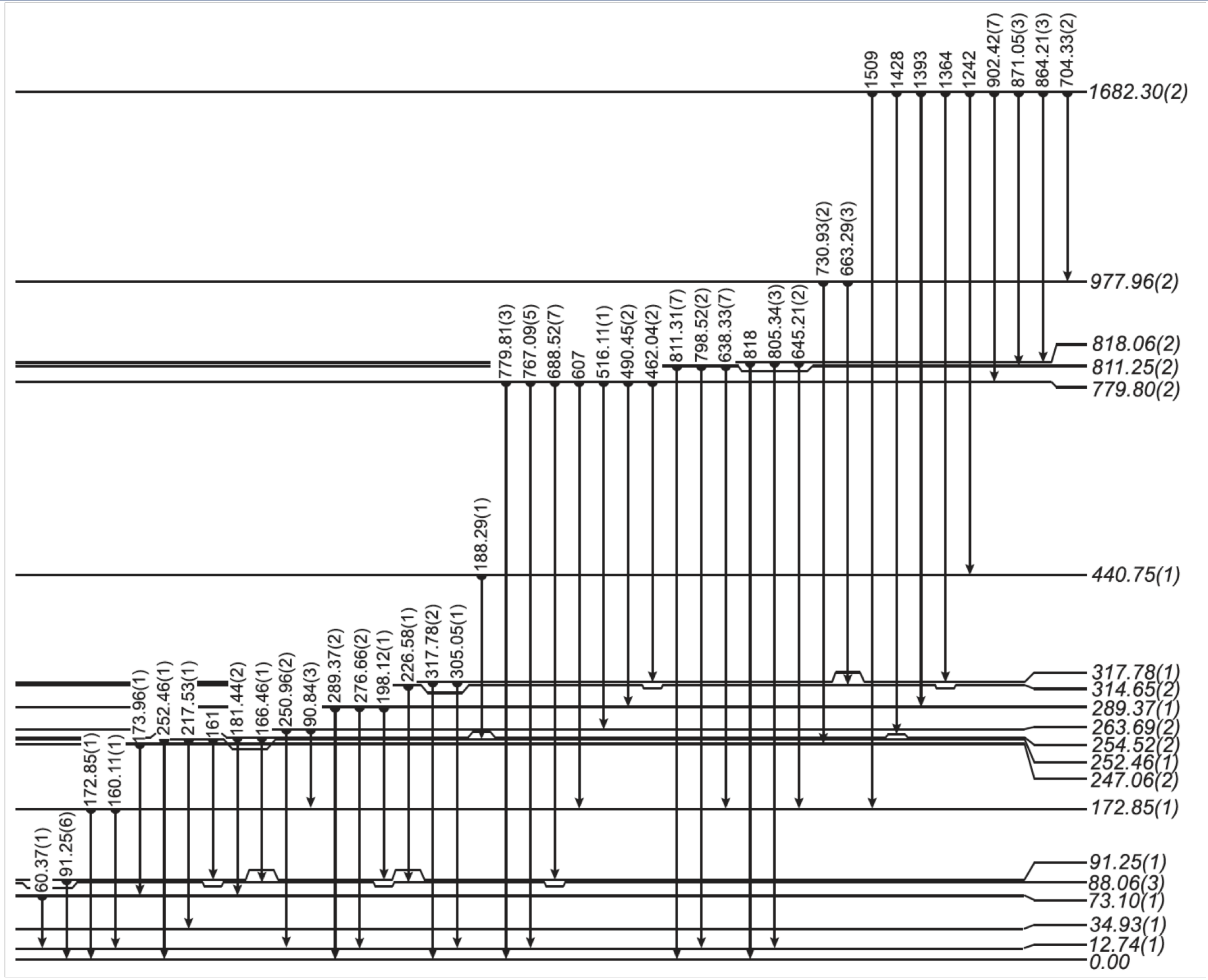
M. Venhart *et al.*, J. Phys. G **44**, 074003 (2017).

Conversion electrons



- Resolution 1.5 keV for electrons above 100 keV

Partial level scheme of ^{183}Au isotope

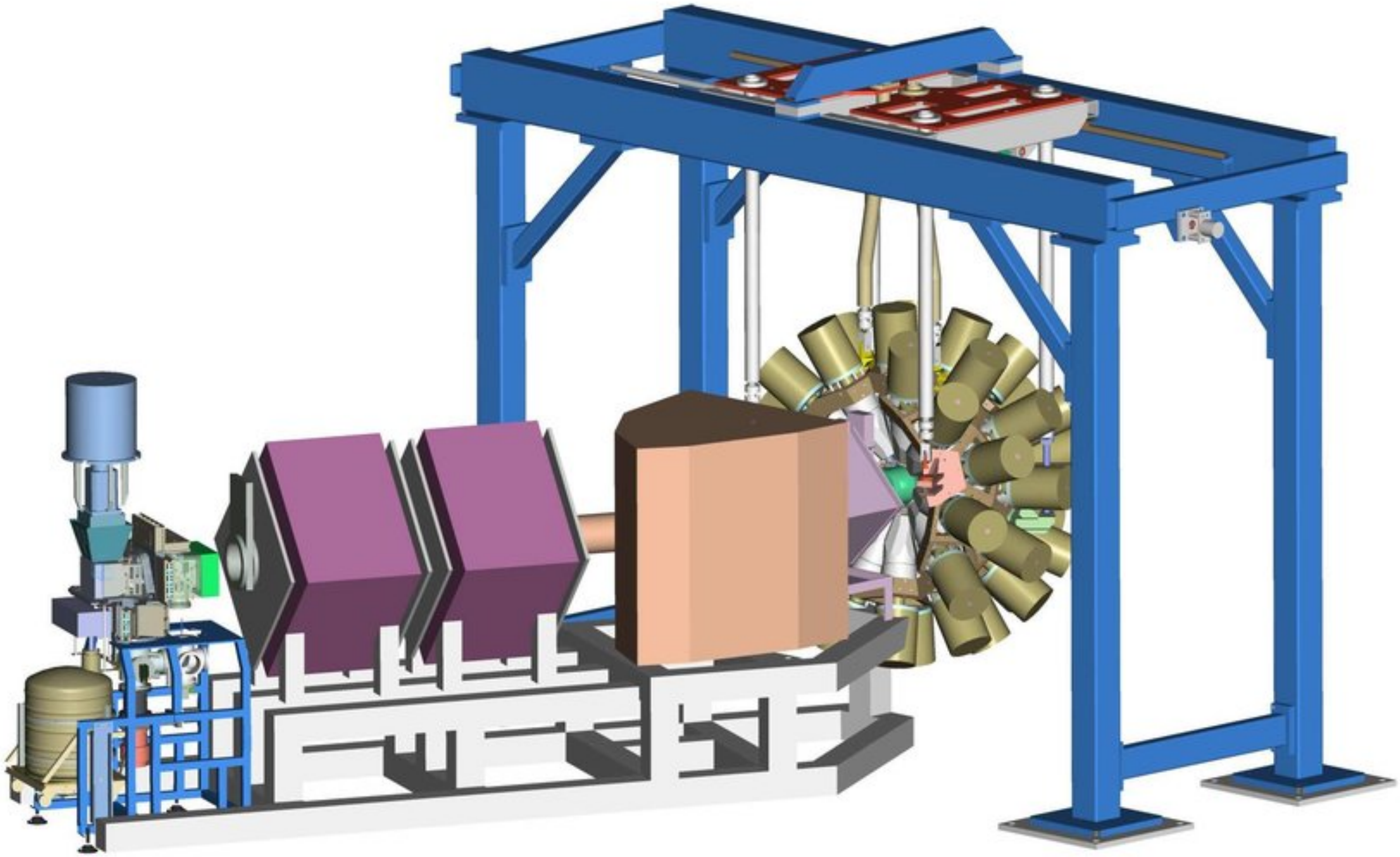


^{183}Au

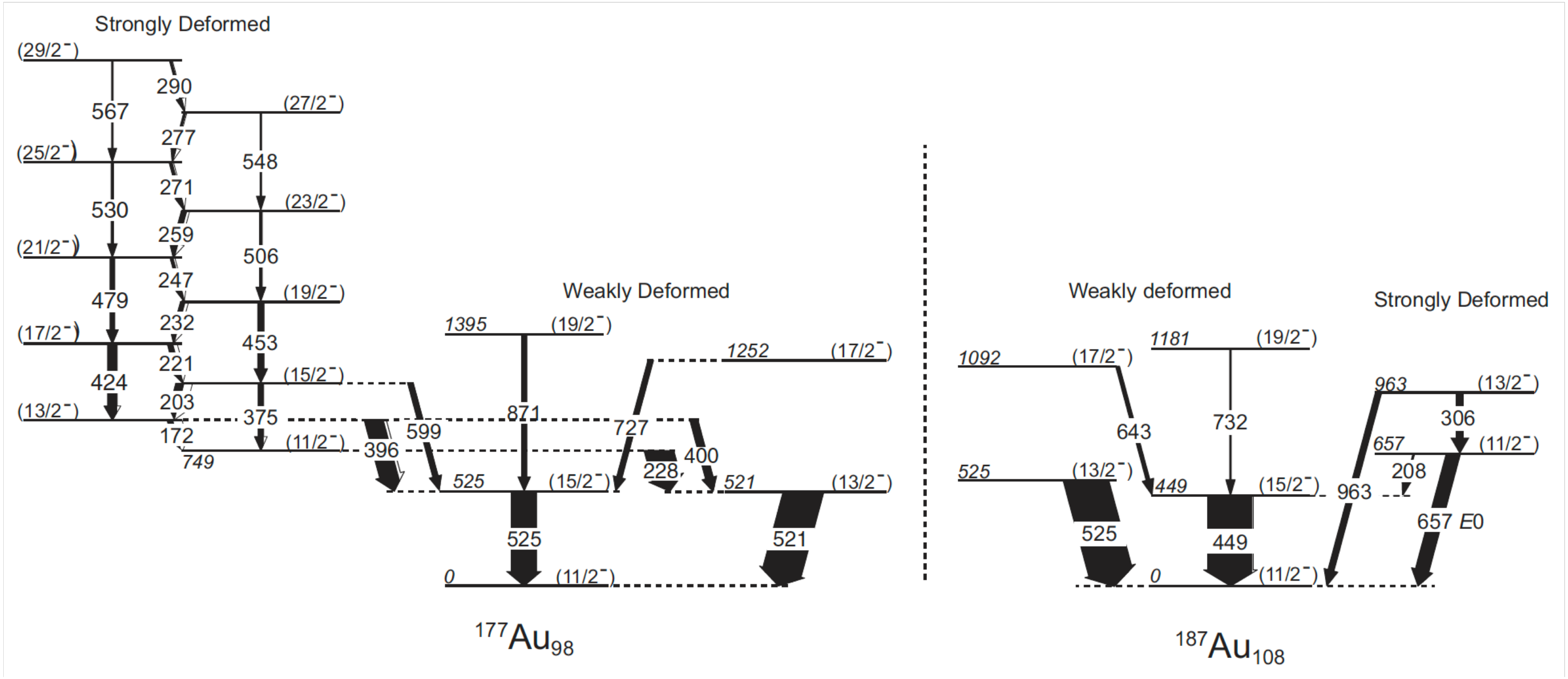
Research programme of odd-Au isotopes - summary

- Commissioning of the system:
  - New ^{183}Au level scheme was constructed – previous level scheme contained serious mistakes
  - ^{181}Au level scheme constructed for the first time (without electrons)
  - *E*0 transitions identified in ^{183}Au
- Reason of failure of previous studies: insufficient resolution and absence of gamma-electron coincidences
- Future: studies of ^{179,181,183,185,187,189}Au isotopes with these techniques: Also know level schemes need revision
- Several interesting new issues found in odd-Au systematics
- In-beam studies in Jyväskylä complement decay experiments

Jurogam2 spectrometer at JYFL

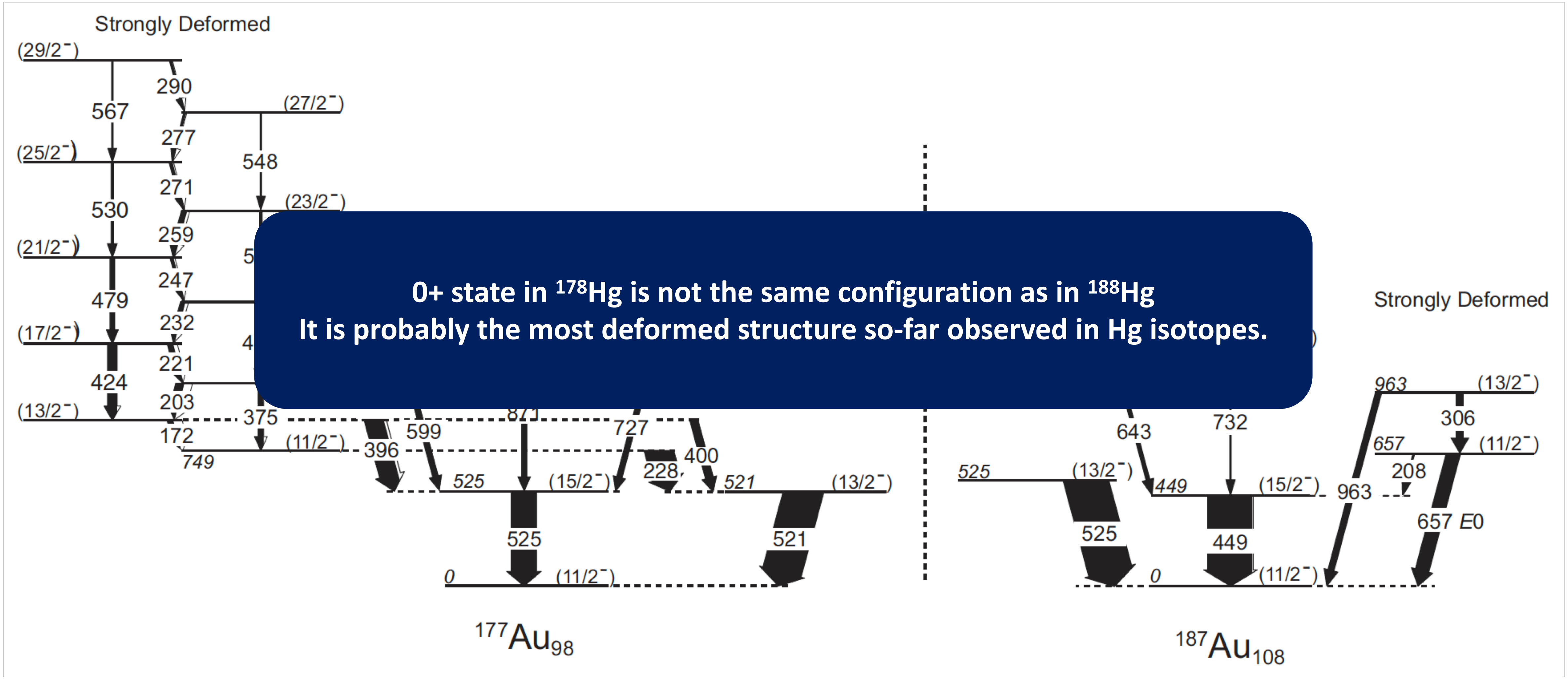


Intruder 0⁺ configuration in ^{178}Hg



M. Venhart *et al.*, Phys. Rev. C **95**, 061302(R) (2017).

Intruder 0+ configuration in ^{178}Hg



0+ state in ^{178}Hg is not the same configuration as in ^{188}Hg
It is probably the most deformed structure so-far observed in Hg isotopes.

M. Venhart *et al.*, Phys. Rev. C **95**, 061302(R) (2017).

List of collaborators

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  - Maria Borge
- **iThemba Labs**
  - Lucky Makhatini
  - Rob Bark
  - Elena Lawrie

Conclusions

- Broad Energy Germanium detector is an excellent choice for decay studies with large density of excited states
- 0^+ intruder state in ^{178}Hg is different from heavier isotopes
    - Life times measurement?
    - Coulomb excitation?

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