Physics of the heaviest N≈Z nuclei

INFN, Laboratori Nazionali di Legnaro

NIPNE Bucharest

INFN and Università di Padova

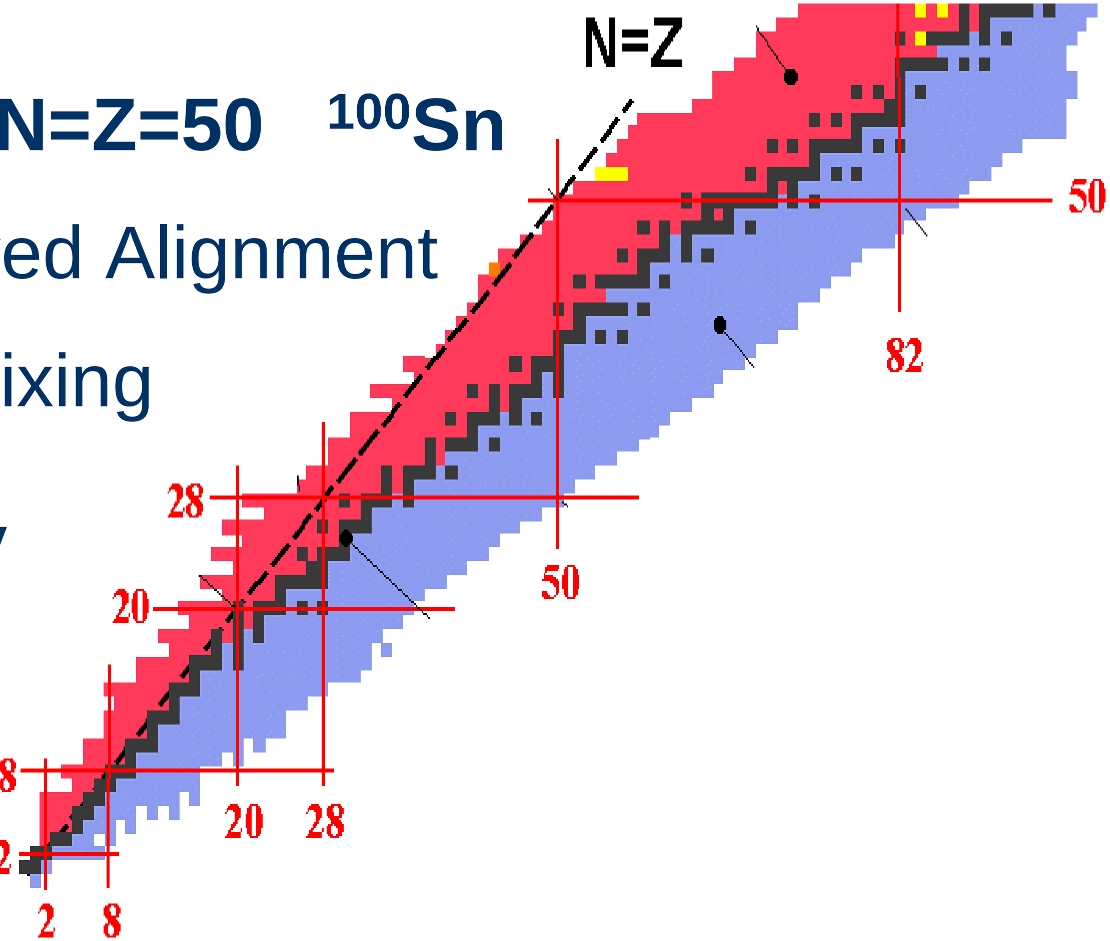
Recent Highlights

N=Z=50 **^{100}Sn**

Delayed Alignment

Isospin Mixing

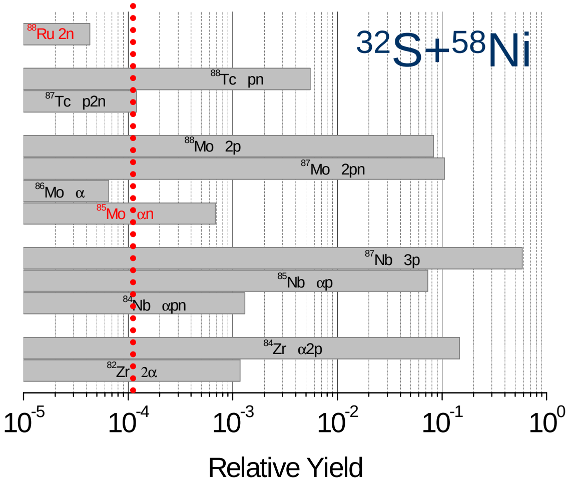
Isospin Symmetry
Breaking



Experimental Study of N≈Z Nuclei

Production
- Fusion-evaporation
- Fragmentation
- Deep inelastic

Low cross sections



Identification
- Coincidence with evaporated particles
- Direct A and Z measurement

Ancillary detectors

Gamma Spectroscopy

High efficiency Ge array

Experimental Facilities

Today : Gammasphere, Rising, CLARA, GASP

Ge arrays with photopeak efficiency ranging from 3% to 10%

GASP

ε_{abs} (Ge) ≈ 3%

Peak/Total ≈ 60%

ε_{abs} (BGO) ≈ 76%

ISIS

$\varepsilon_p \approx$ 56-60%

$\varepsilon_\alpha \approx$ 35-38%

N-Ring

$\varepsilon_n \approx$ 2-5%

Recent results with GASP

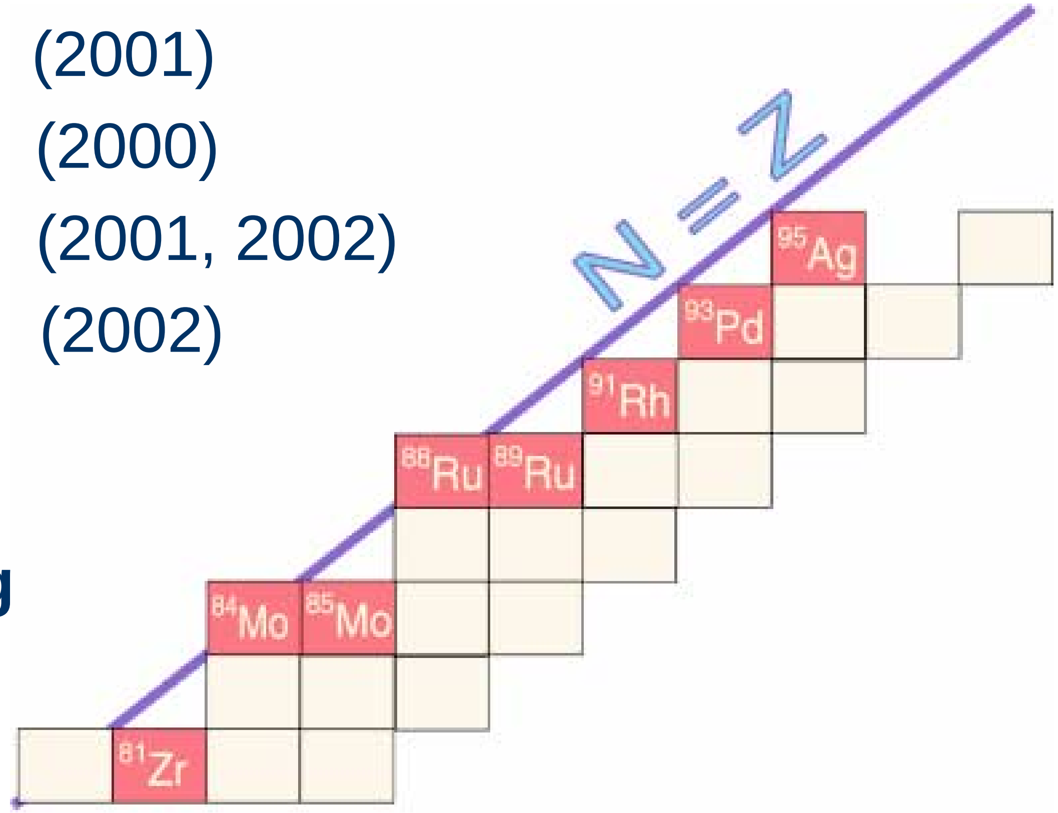
^{28}Si(90 MeV) + ^{58}Ni (2001)

^{32}S(105 MeV) + ^{58}Ni (2000)

^{40}Ca(130 MeV) + ^{54}Fe (2001, 2002)

^{40}Ca(135 MeV) + ^{58}Ni (2002)

GASP + ISIS + N-Ring

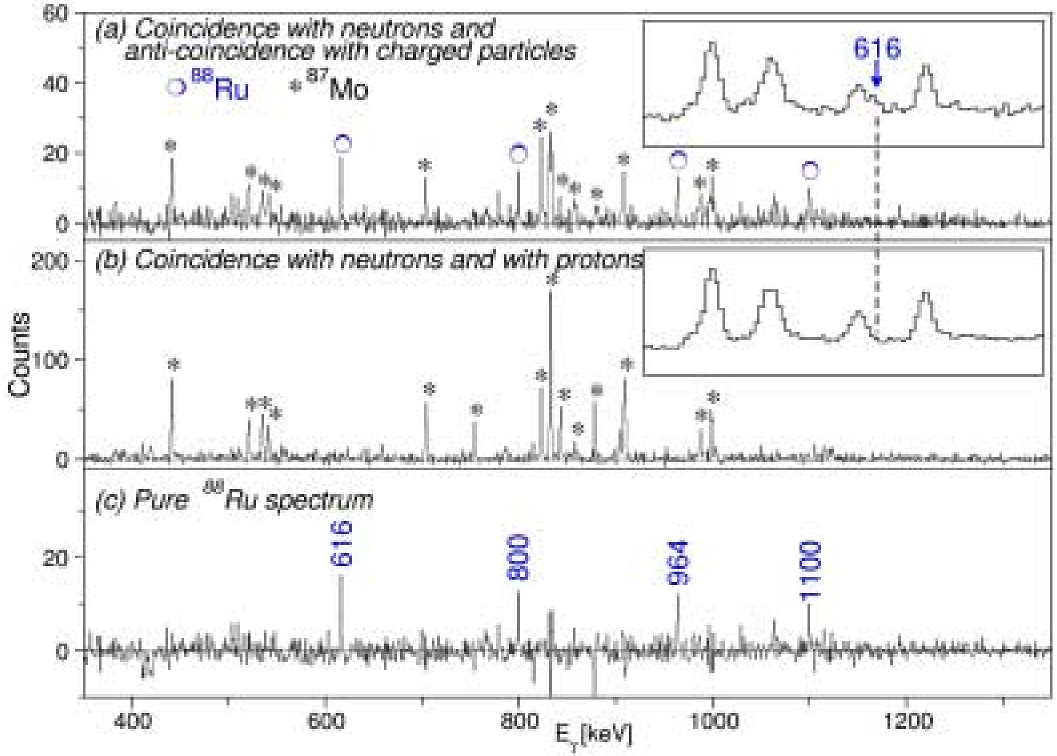


Gamma Spectroscopy of Heavy N=Z Nuclei

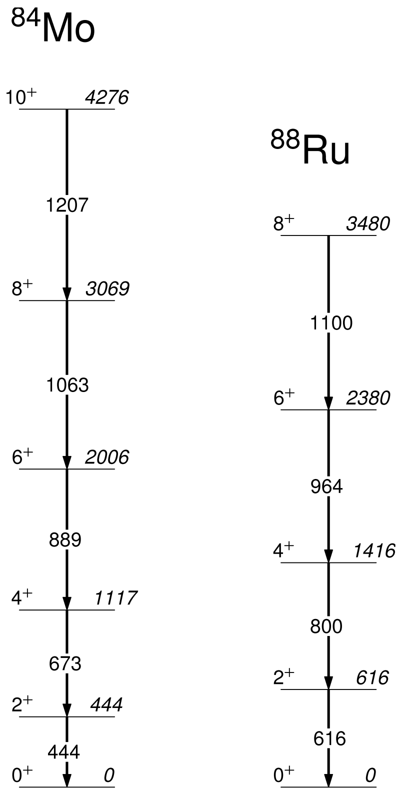
^{88}Ru

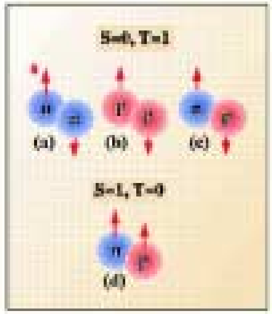
Experiment: ^{32}S + ^{58}Ni

- Backed target, 1mg/cm^2 ^{58}Ni on 10 mg/cm^2 Au
- ^{88}Ru populated as ***2n*** channel
- Intensity ≈ **4·10^{-5}**
- Four gamma ray cascade identified in coincidence with neutrons and not coincident with charged particles

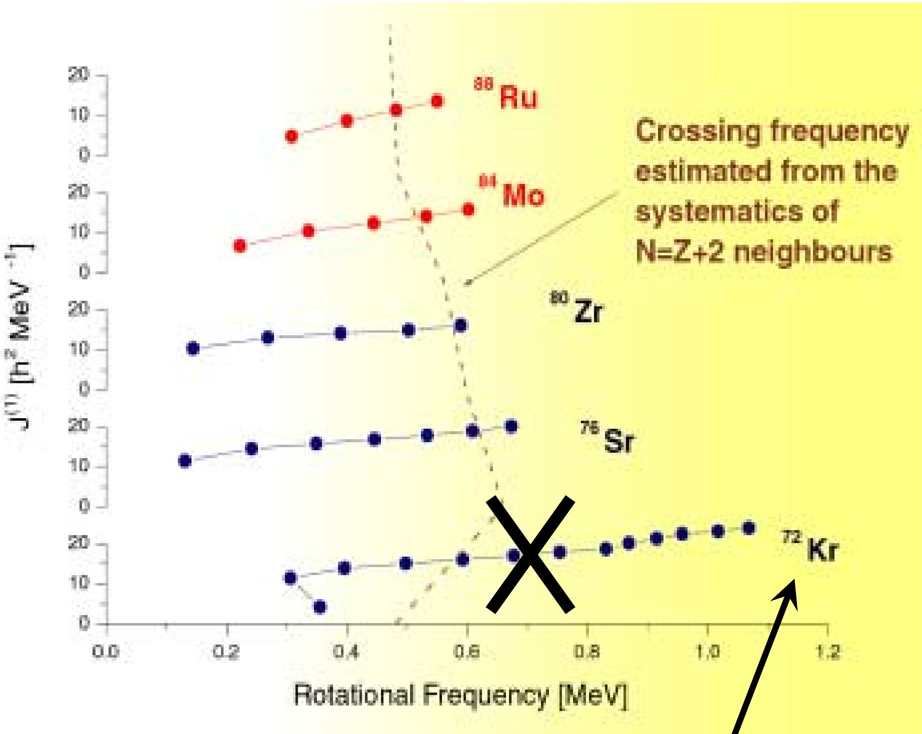


Delayed Alignment in N=Z Nuclei





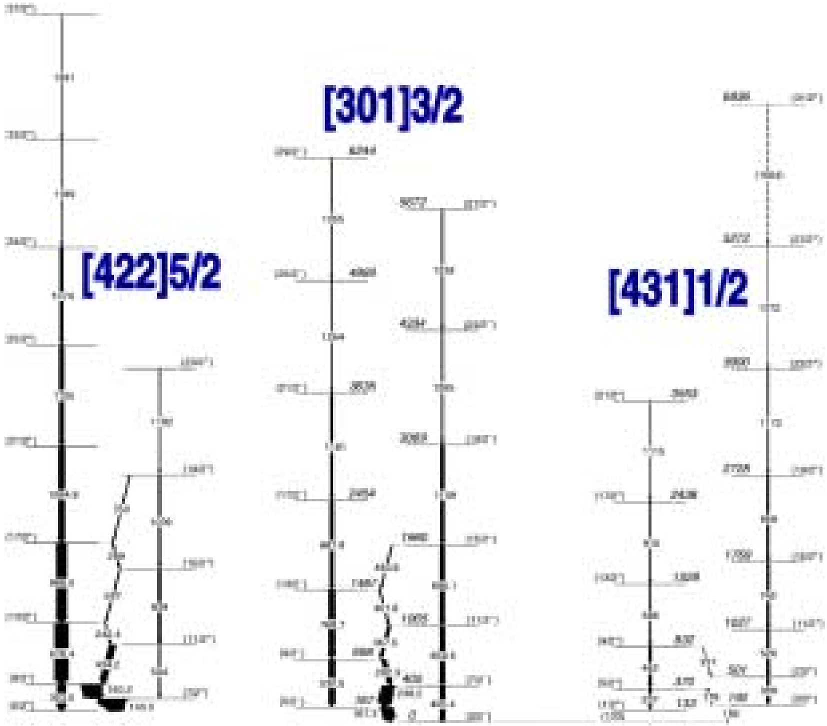
Effect of T=0 pairing



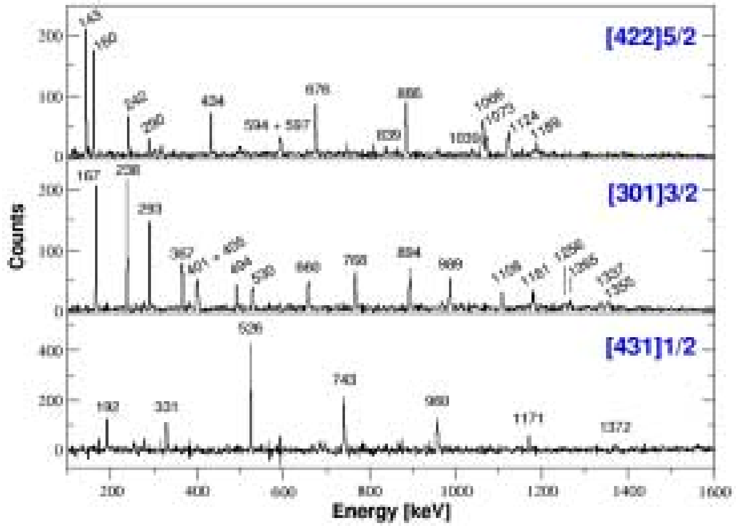
Forking, shape cohexistence

N=Z+1 Nuclei

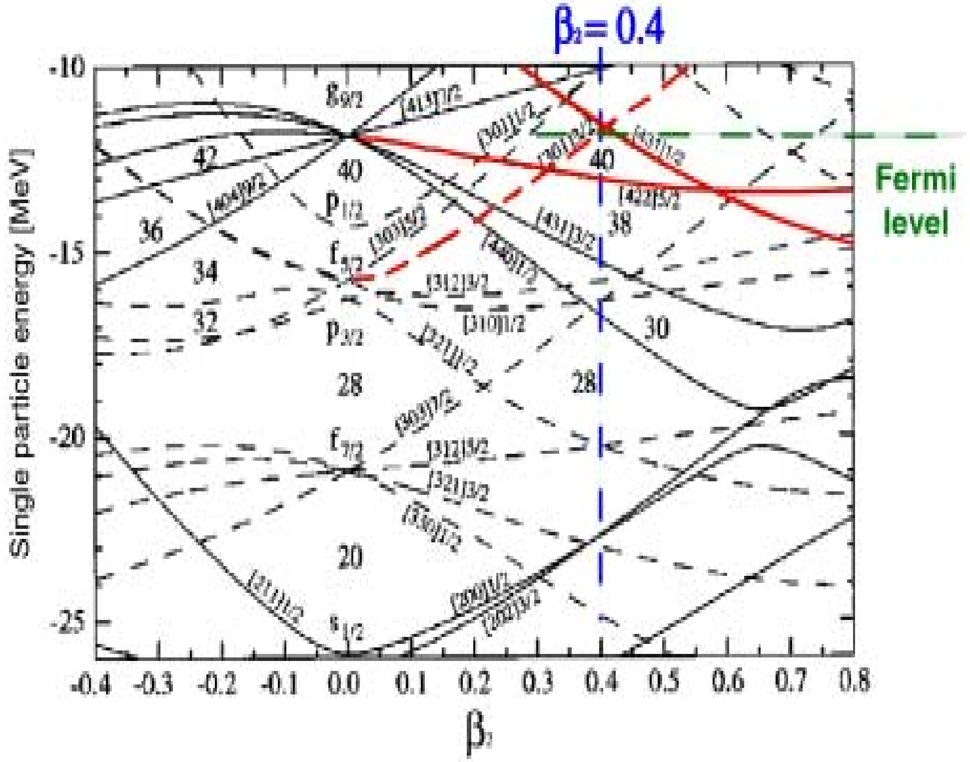
^{81}Zr

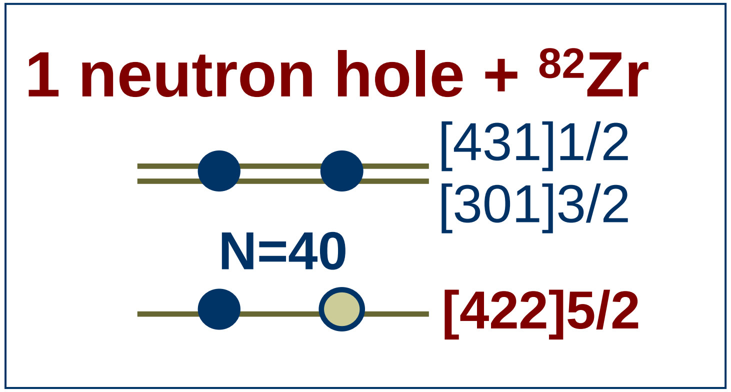


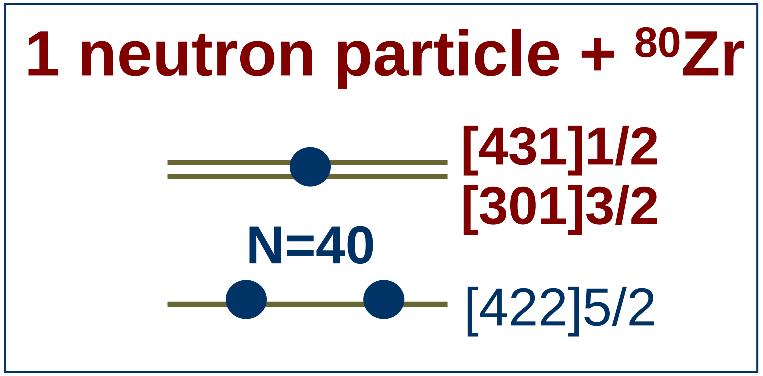
Identified with GASP



Band structures in ^{81}Zr

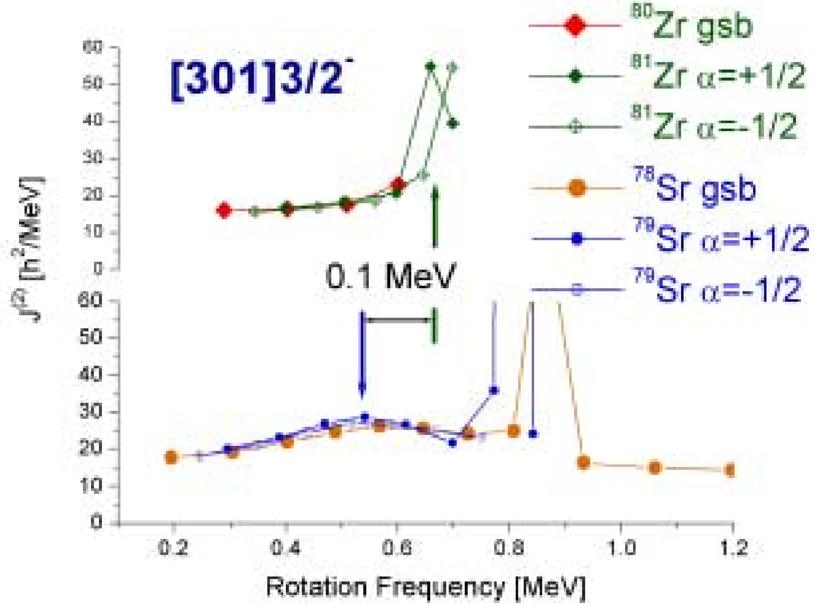




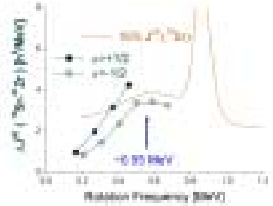


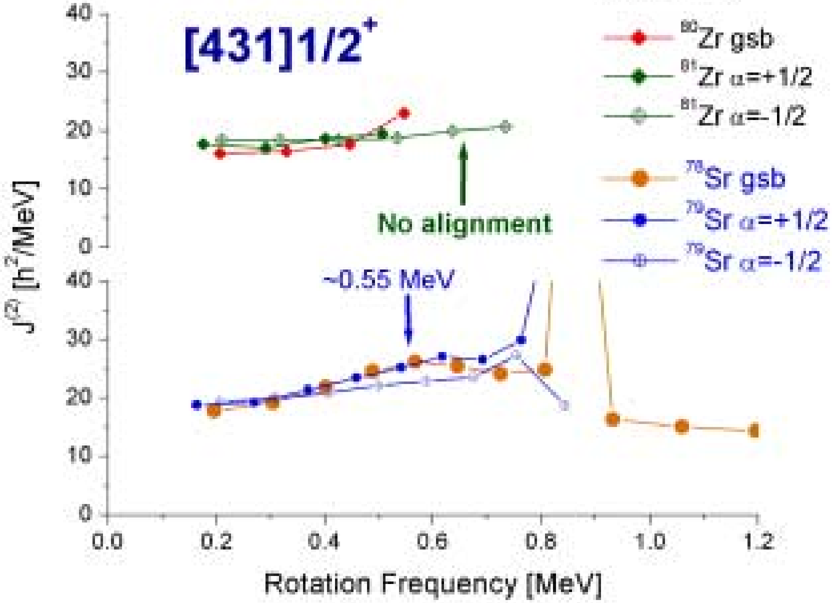
Delayed Alignment in 81Zr

Estimate for the alignment frequency of ^{80}Zr



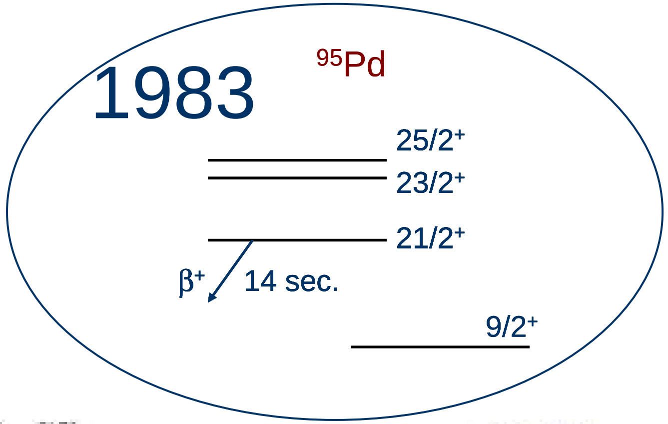
Missing alignment





High-spin isomers around N=Z=50

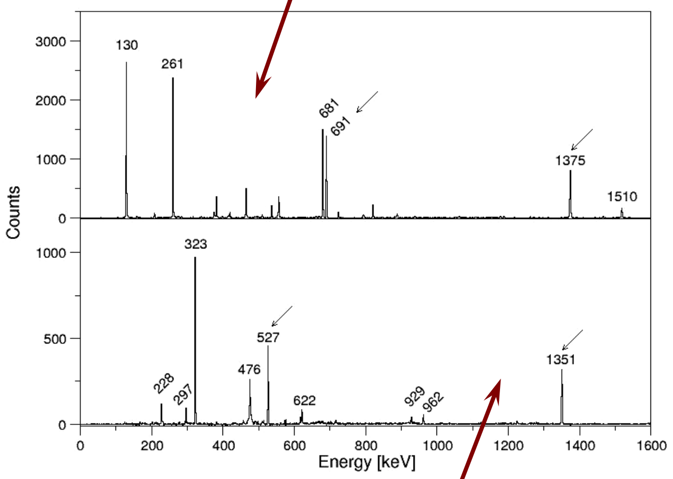
In SM calculations the correct prediction of the spin-gap isomeric states depends critically on the magnitude of the $\langle 1g_{9/2}^2 | V_{pn} | 1g_{9/2}^2 \rangle_{J=9}$ matrix element



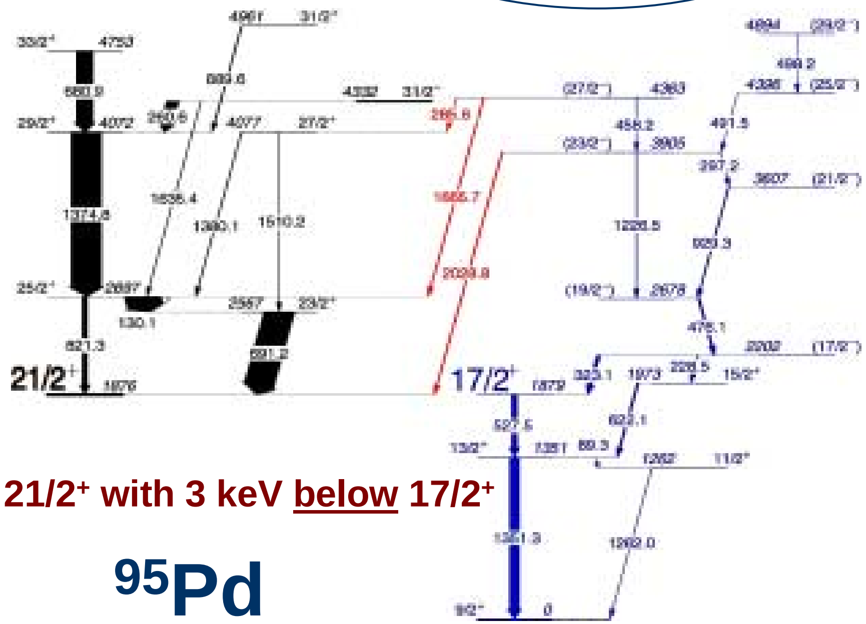
Relative Yield ~ $5 \cdot 10^{-2}$

GASP + ISIS + N-Ring

Above 21/2$^+$ isomer



Below 21/2$^+$ isomer



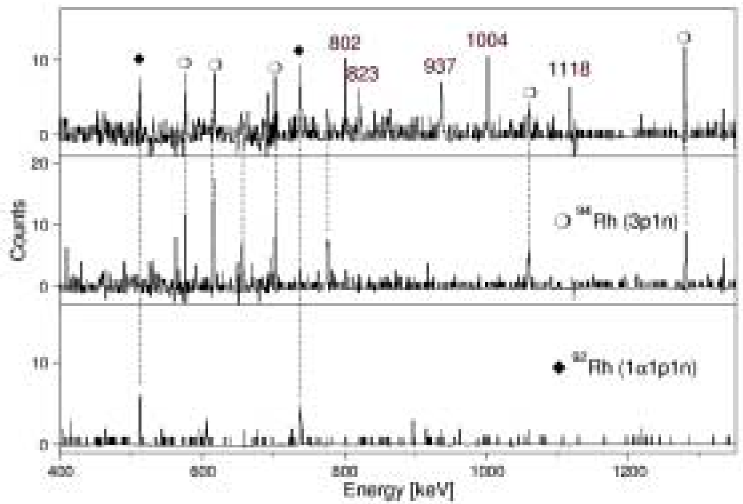
21/2$^+$ with 3 keV below 17/2$^+$

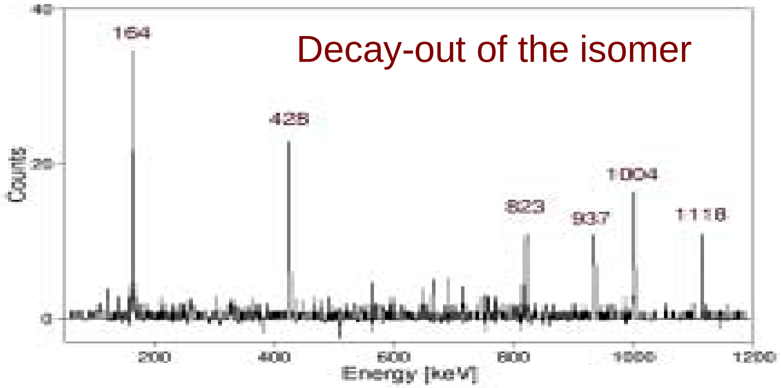
^{95}Pd

Isomeric decay of ^{95}Ag

Relative Yield ~ 10^{-4}

Prompt coincidence with neutrons



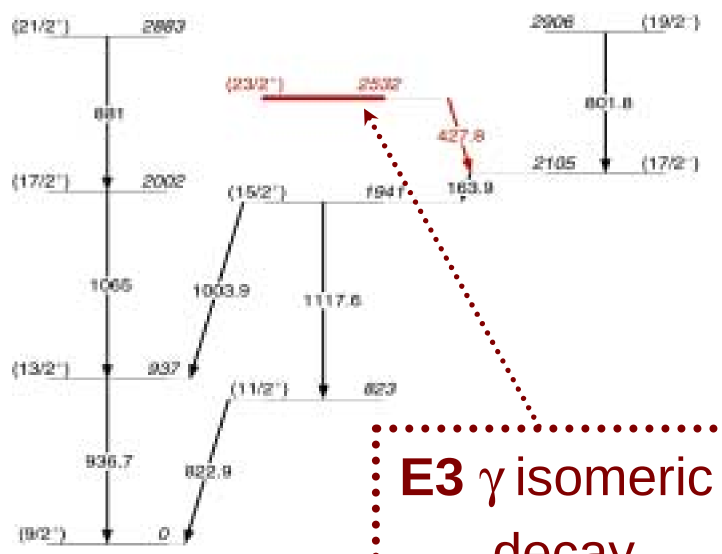


Decay-out of the isomer

^{40}Ca + ^{58}Ni

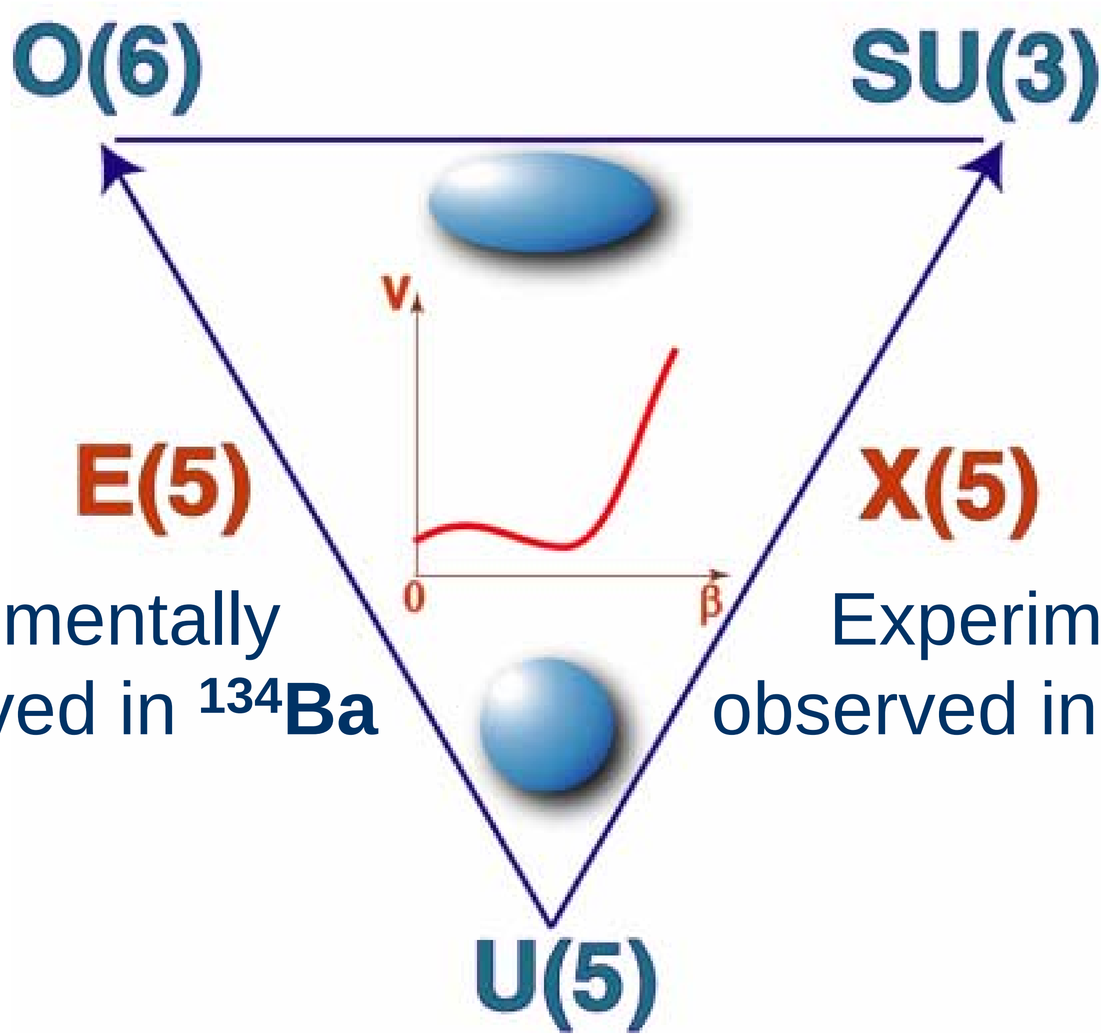
GASP + ISIS + N-Ring

95Ag



E3 γ isomeric decay

Critical-Point Symmetries



Experimentally observed in ^{134}**Ba**

Experimentally observed in ^{152}**Sm**

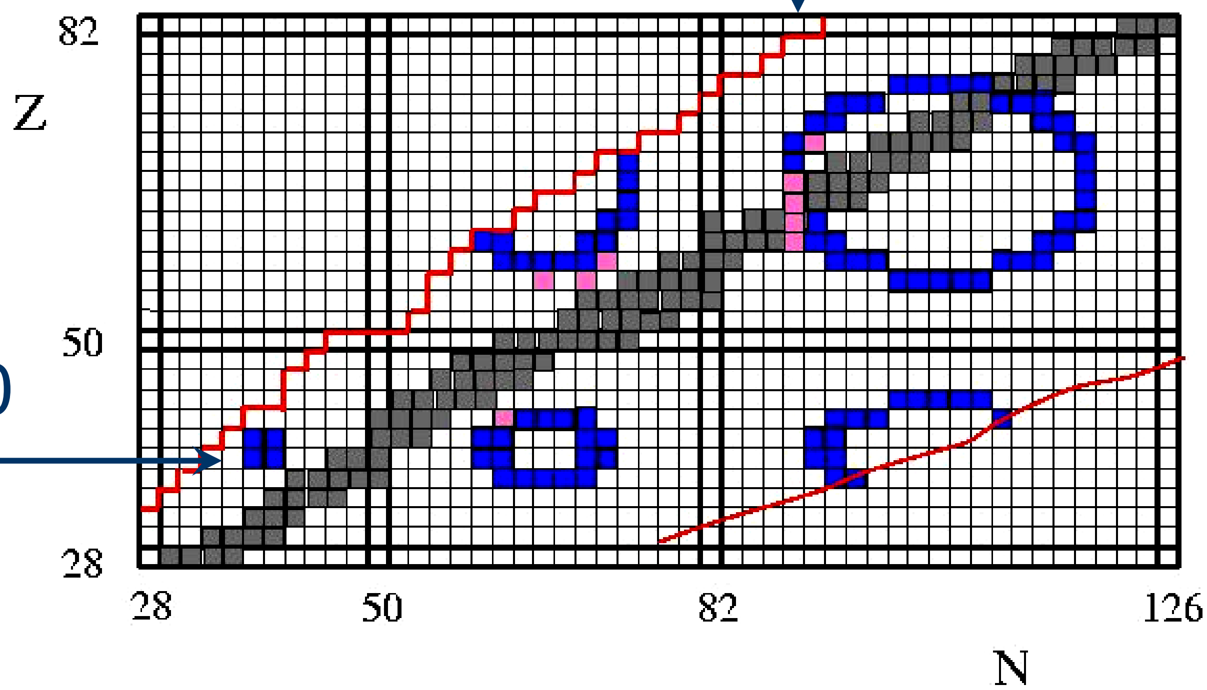
Predicted X(5) Regions

$4.5 < N_pN_n/(N_p+N_n) < 5.5$

N.V. Zamfir, private comm.

N = 90 nuclei

N=Z = 38,40



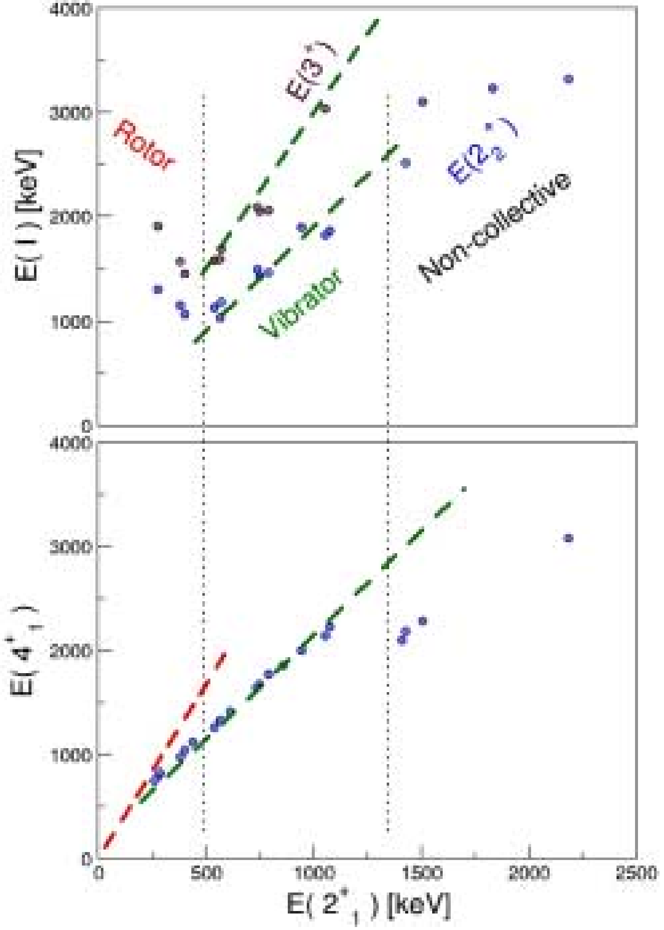
Quasi-γ Bands

Quasi-γ bands identified or completed in ^{78}Sr, ^{80}Sr, ^{82}Zr, ^{84}Zr, ^{86}Zr, ^{86}Mo, ^{88}Mo

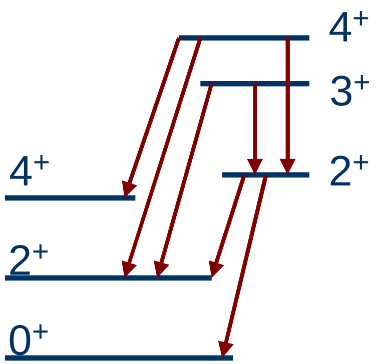
⇓

The plot of $E(2^+_\gamma, 3^+_\gamma)$ versus $E(2^+_1)$ clearly indicates the ***Rotor-Vibrator phase transition***

Even-even Sr-Zr-Mo with N≤50

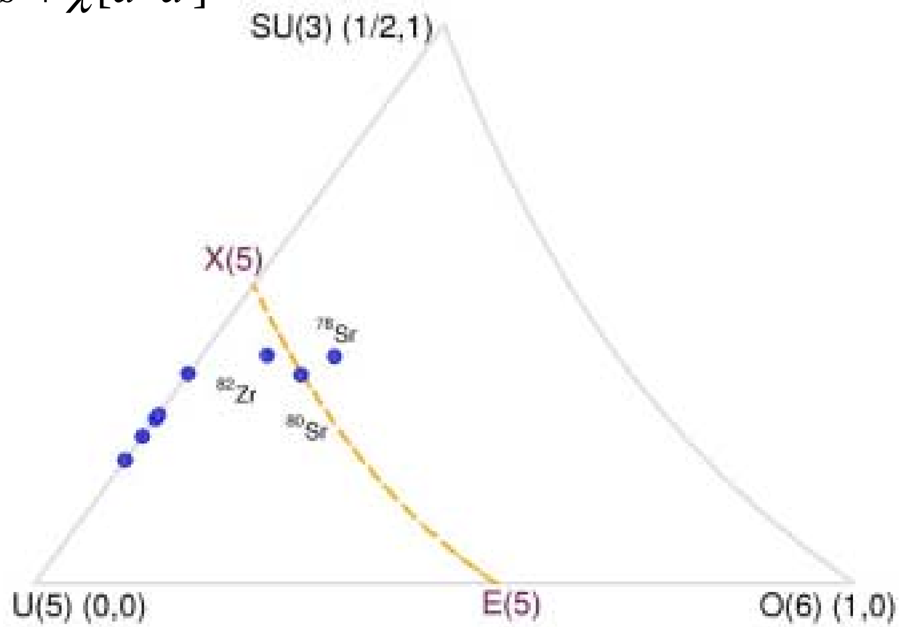


Phase Transition In IBA Triangle



$$H_{IBA} = a\left[(1-\zeta)n_d - \frac{\zeta}{4N}(Q\cdot Q) + \zeta'\cdot(L\cdot L)\right]$$

$$Q = s^+\tilde{d} + d^+\tilde{s} + \chi[d^+\tilde{d}]^{(2)}$$

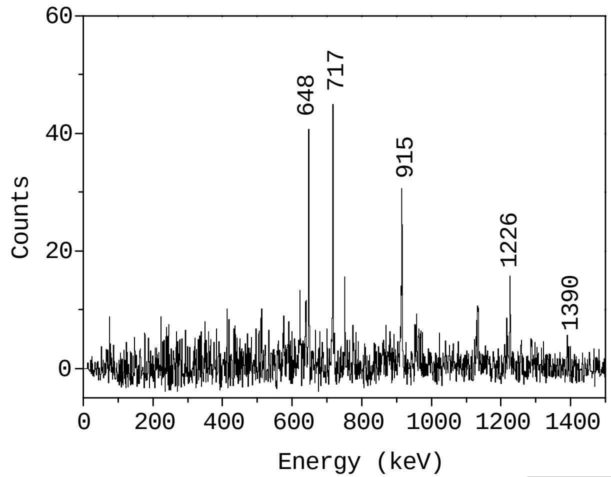


- Fine grid on parameter space
- χ^2 merit function including both energy and branching ratios

New parameters: $x = \zeta \cdot \dfrac{1}{1+\dfrac{|\chi|}{\sqrt{7/2}}}$ $\qquad y = \dfrac{\zeta\cdot|\chi|}{\sqrt{7/2}}$

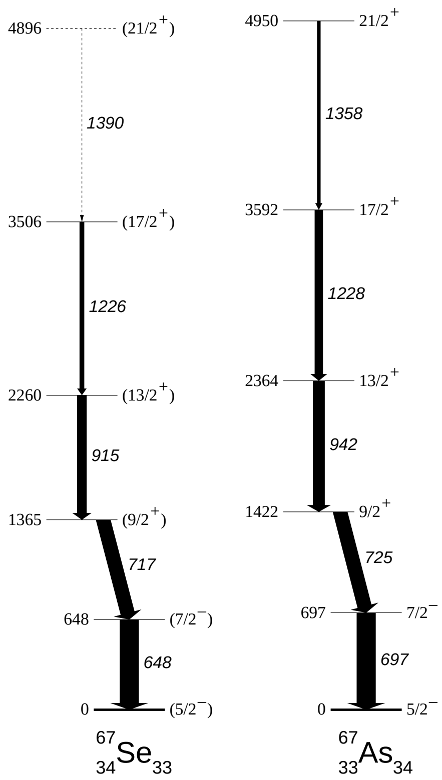
Mirror Nuclei Above N=Z=28

EUROBALL + Euclides + N-Wall ^{32}S(90MeV)+^{40}Ca

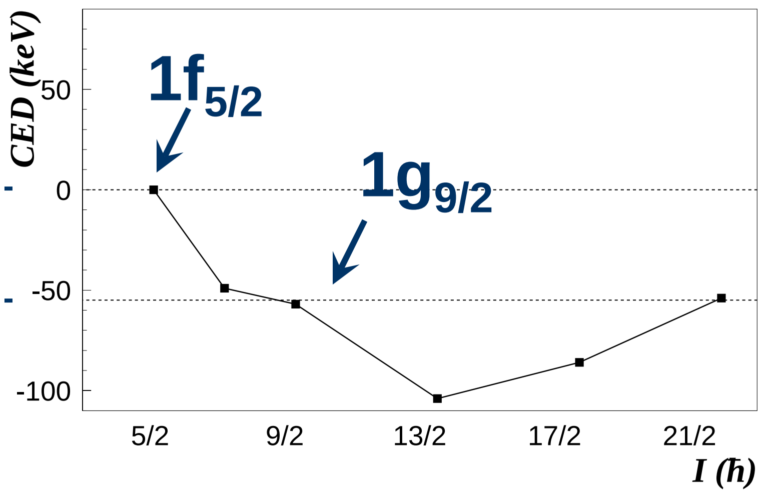


^{67}Se – ^{67}As

mirror pair



Electromagnetic
spin-orbit
contribution



Open Problems

Delayed alignment ⟹ Higher-spin states

Mirror nuclei
Heavier N~Z nuclei ⟹ Identification

Critical-point symmetries ⟹ Non-yrast states

What we need

- With stable beams :
  - Higher gamma detection efficiency
  - Efficient neutron and charged-particle detectors
- Radioactive beams :
  - At least higher gamma detection efficiency

Need For AGATA

Stable beam Radioactive beam	low cross section low beam intensity	High γ detection efficiency
Deep inelastic Fragmentation	High recoil velocity	Good γ position resolution
	Huge background	Efficient ancillary detectors

AGATA + ancillary detectors