In-beam spectroscopy of ^{94}Ag

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Motivation

The concept of isospin has been introduced to account for the apparent charge independence of the nucleon-nucleon interaction. However, the Coulomb force cannot account for all deviations, suggesting that other isospin-symmetry-breaking components must be present.

N~Z systems present the perfect testing ground to probe isospin symmetry phenomena. In particular, pairing correlations have a significant influence in N=Z nuclei, favouring T=0 np pairing instead of the normal T=1. It was recently suggested that spin-aligned T=0 np pairs dominate the wavefunction of the γ-rast sequence in ^{92}Pd [1]. Subsequent theoretical studies [2-4] were devoted to probe the contribution of np pairs in other N=Z A>90 nuclei, suggesting the potential for a similar pairing scheme.

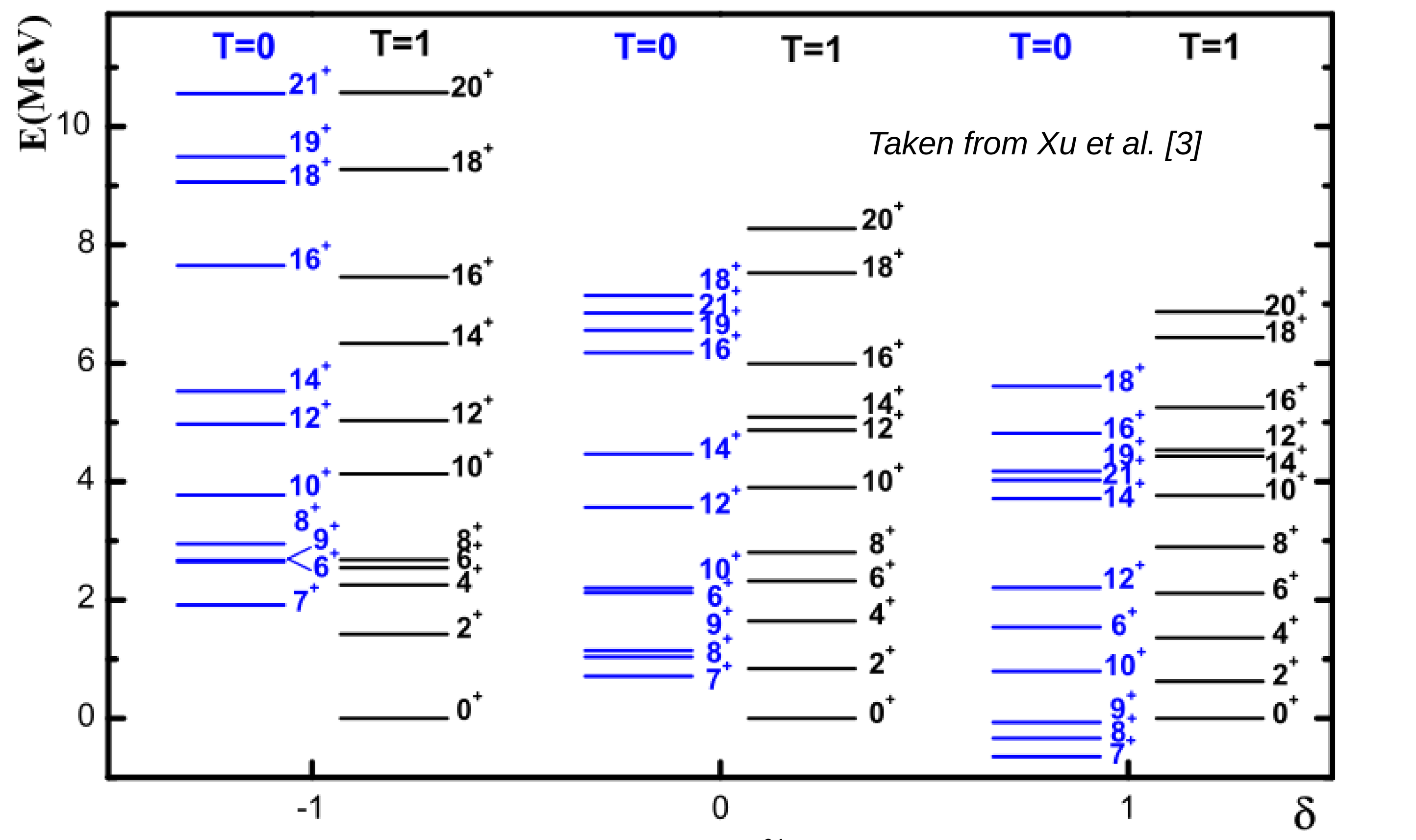


Figure 1: Shell model predicted T=0 and T=1 states in ^{94}Ag calculated in the as a function of 0g9/2 shell np-spin-aligned interaction matrix element δ [V(δ) = V(0)(1+δ)].*

Experimental setup

A recoil beta tagging experiment for the identification of the T=0 and T=1 states in ^{94}Ag using the ^{40}Ca(^{58}Ni,p3n)^{94}Ag reaction was performed at the Accelerator Laboratory of the University of Jyväskylä.

- **GREAT** focal plane detection system:
  - MWPC
  - DSSSD
  - Planar Ge detector
  - Ge clover detectors
- HPGe detector array **Jurogam3**.
- **JYTube** charged particle veto detector.
- **MARA** mass spectrometer

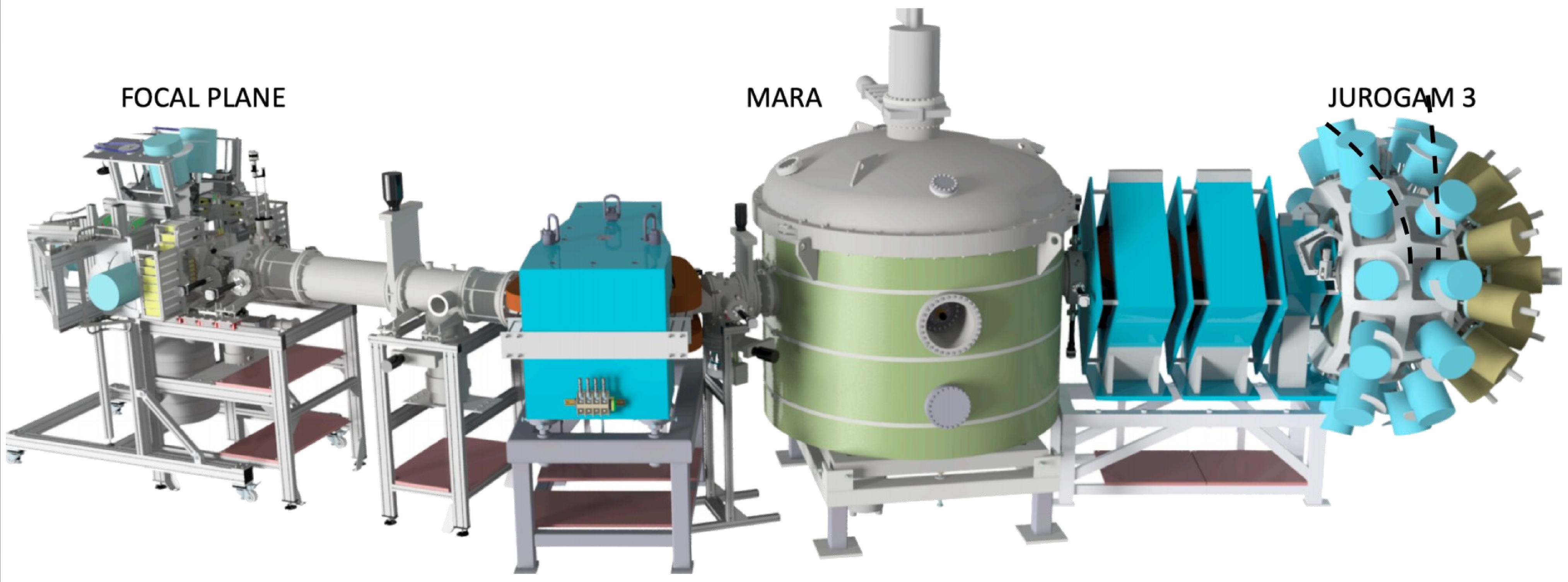


Figure 2: Schematic drawing of the experimental setup. From left to right, GREAT focal plane detector system, MARA mass spectrometer, JUROGAM3 germanium detector array and (hidden) JYTube charged particle veto detector.

All detector signals were time stamped to allow temporal correlations between γ-rays, charged-particles, recoils and decays.

Results

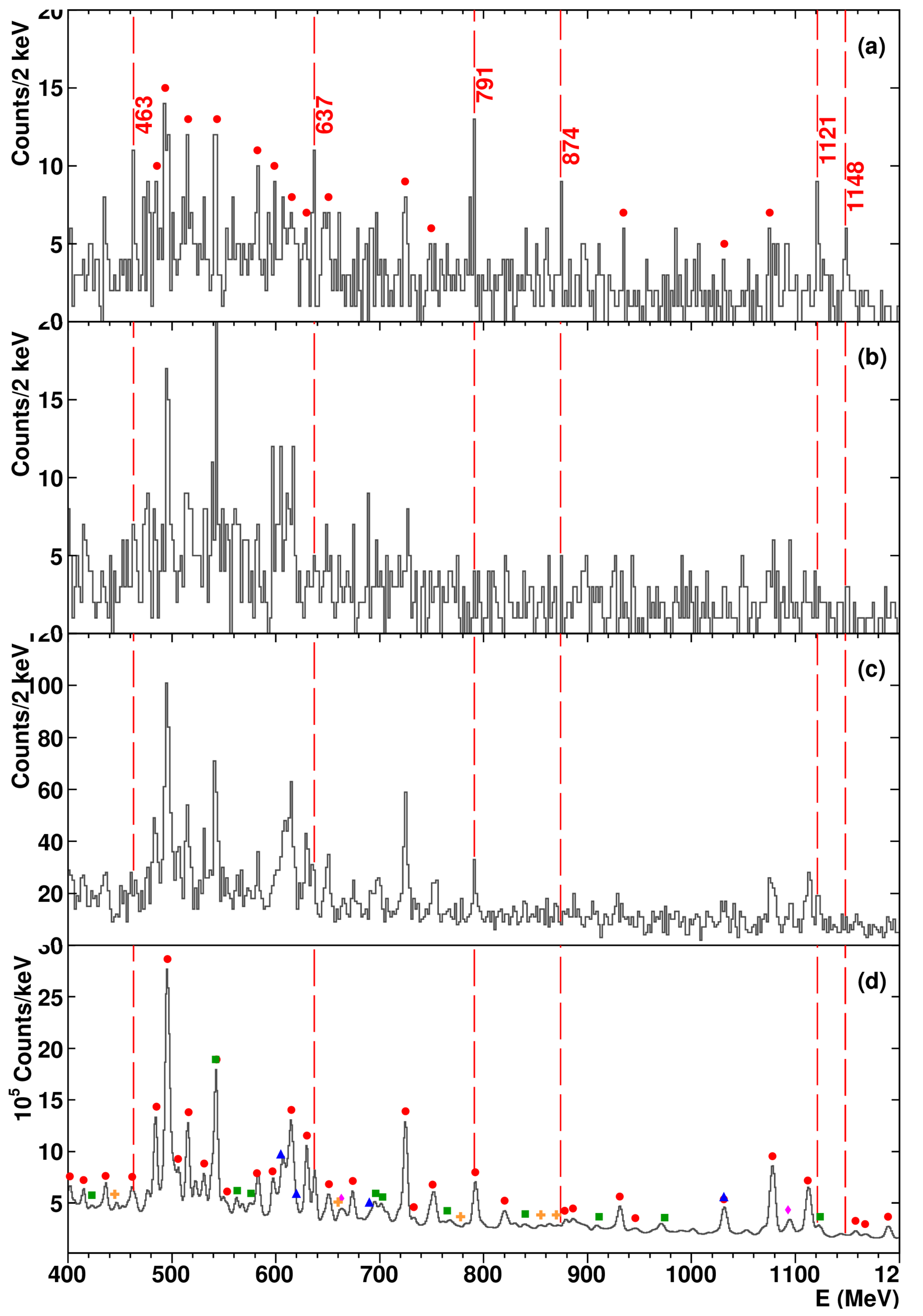
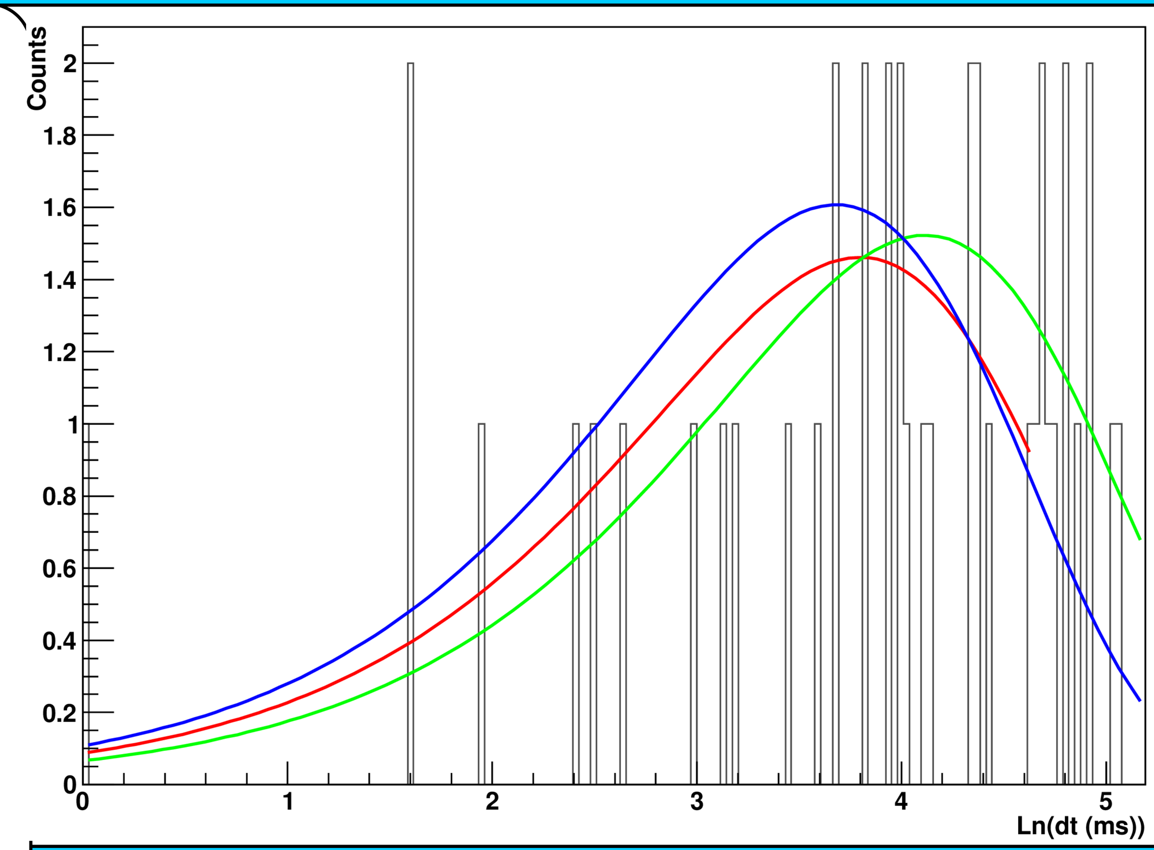


Figure 3: Doppler corrected spectra for prompt γ-ray in coincidence with A=94 recoils decaying within 60 ms (a) or between 120 and 180 ms (b) from implantation and rejecting events detecting 2 or more charged particles. Panel c) shows prompt γ-rays in coincidence with short-lived A=94 recoils (dt<60 ms) and 2 or more charged particles and d) presents the prompt γ-rays in coincidence with A=94 recoils. Highligthed in red are shown the ^{94}Ag transitions identified in this work. Known transitions of ^{94}Ru (●), ^{94}Rh (■), ^{94}Tc (▲), ^{94}Mo (♦) and ^{90}Mo (+) in are shown in d).



Half-life

The half-life of the recoils implanted in coinci-dence with these γ-ray transitions was estimated using the Schmidt method [5] (figure 4).

Figure 4: Natural logarithm of the decay time measured for recoils in coincidence with γ-rays tentatively assigned to ^{94}Ag. The solid green and red curves represent the log likelihood fit to decays within 180 ms and 120 ms from implantation respectively, from whose centroid a halftime of 41(13) and 30(13) ms is estimated. The solid blue curve is a calculation corresponding to the currently accepted value of 27(2) ms.

This analysis suggest that the γ-rays at 274, 463, 637, 791, 874, 1121 and 1148 keV observed in this work are associated with a short-lived β-decaying A=94 nucleus, produced via one-charged particle evaporation channel and whose half-life is consistent with the currently accepted value for the ^{94}Ag ground-state β-decay.

Discussion

- No clear level scheme for ^{94}Ag.
- Relying on analog ^{94}Pd to deduce CED
- Compared to shell model predictions (JUN45).
  - Agreement on drecreasing trend
  - Th calculations shifted ~35 keV

Interestingly, shell model calculations suggest that we should only see the $2^+ \rightarrow 0^+$ (T=1) decay, with the other strong γ-rays involving a T=0 state as an initial or final state (or both), as shown in figure 6a where E2 transitions from the 6^+ to the 4^+ and 4^+ to 2^+ are highly supresed. However, if T=0 states lie ~750 keV higher in energy than shell model calculations predict, then the T=1 sequence becomes the dominant path of decay (see figure 6b).

Determinig the relative position of the 0^+ T=1 ground state and the 7^+ T=0 isomer will provide important information to answer this question.

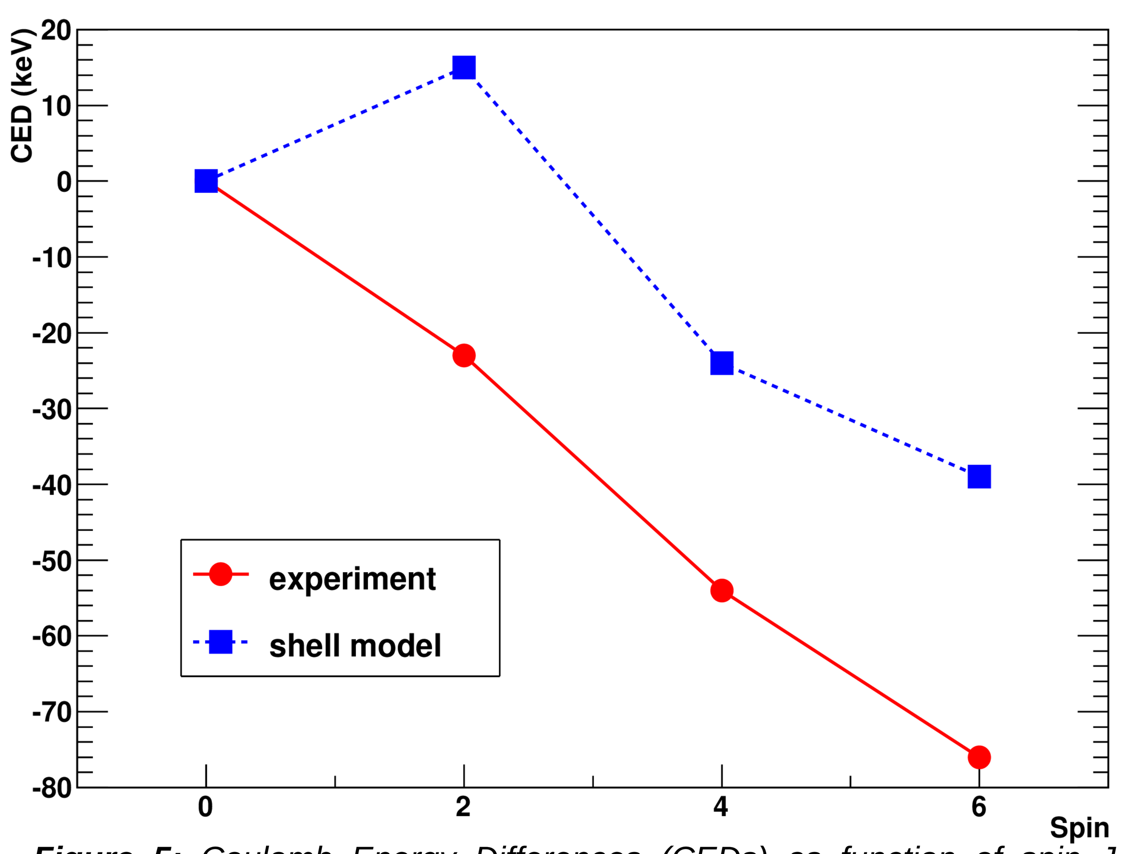


Figure 5: Coulomb Energy Differences (CEDs) as function of spin J between tentatively assigned T=1 levels in ^{94}Ag and corresponding pairs in ^{94}Pd. Experimental values (●) are compared with shell model predictions (■).

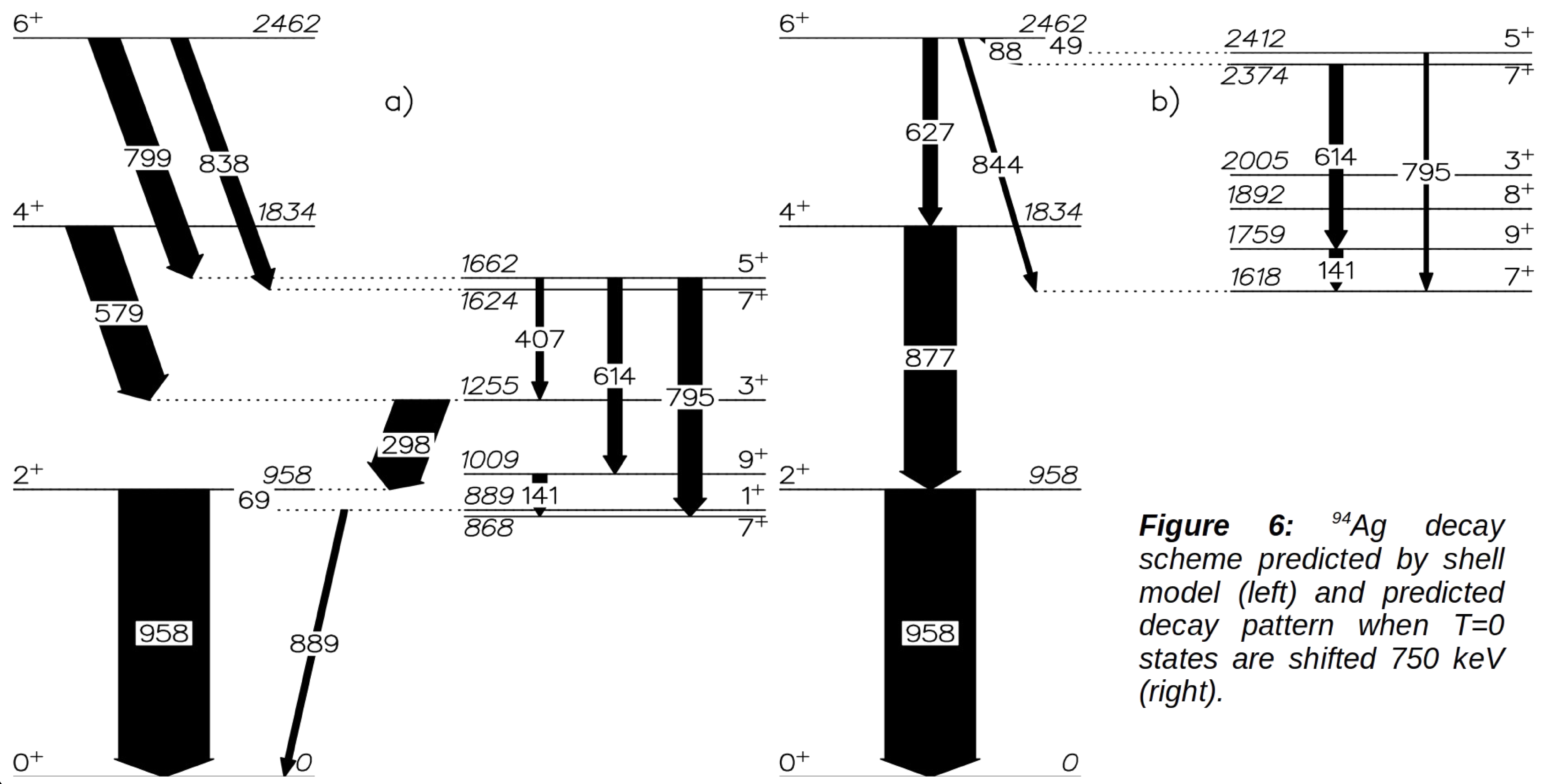


Figure 6: ^{94}Ag decay scheme predicted by shell model (left) and predicted decay pattern when T=0 states are shifted 750 keV (right).

References

[1] B. Cederwall et al., Nature 469 (2011) 6871.
[2] S. Zerguine and P. Van Isacker, Phys. Rev. C 83 (2011) 064314.
[3] Z.X.Xu, C. Qi, J. Blomqvist, R.J. Liotta, R. Wyss, Nucl. Phys. A 877 (2012) 51-58.
[4] G.J. Fu, J.J. Shen, Y.M. Zhao and A. Arima, Phys. Rev. C 87 (2013) 044312.
[5] K.H. Schmidt, C.C. Sahm, K. Pielenz and H.G. Clerc, Z. Phys. A - Atoms and Nuclei 316 (1984) 19-26.
[6] J. Park et al., Phys. Rev. C 99 (2019) 034313.
[7] K. Moschner et al., EPJ Web of Conferences 93 (2015) 01024.

Acknowledgements

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