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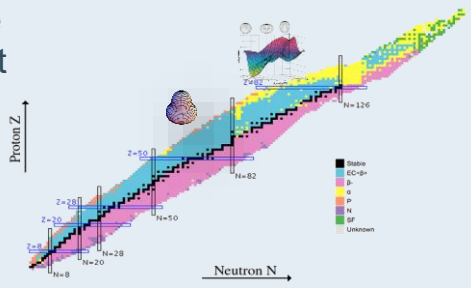
Gamma-ray spectroscopy of ^{229}Ac following the β decay of ^{229}Ra

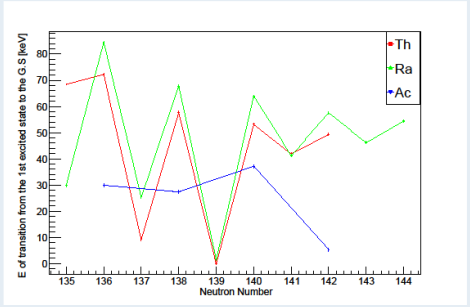
M. Satrazani on behalf of the IDS Collaboration

Motivation

- The appearance of intruder configurations right above the Fermi levels and close to orbitals with $\Delta L = \Delta J = 3$, along with the occurrence of low-lying negative parity states, indicate an **octupole deformation** that gives rise to an asymmetric pear-shaped form [1,2,3,4].



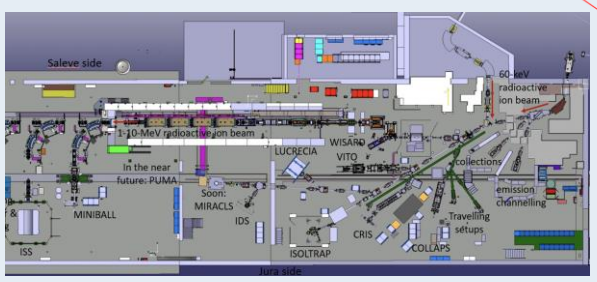
- The nuclei in the **actinide region** (Z≥89) exhibit a range of deformation behaviours from quadrupole to octupole.
In particular, ^{229}Ra exhibits parity doublets linked to octupole shapes [5], while ^{229}Th hosts an ultralow ~8.2 eV state of interest for nuclear-clock research [6,7].

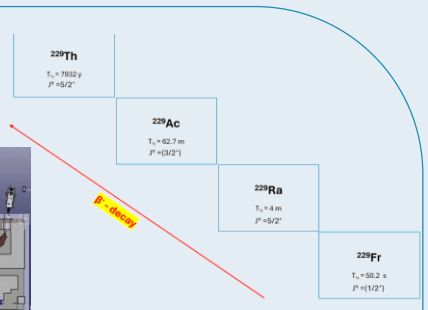


- ^{229}Ac is a neutron-rich odd-even nucleus located right in the middle of the spherical shell closure (N = 126) and the deformed shell closure (N=152) and thus, a unique candidate to study shape phenomena [8].

Experiment

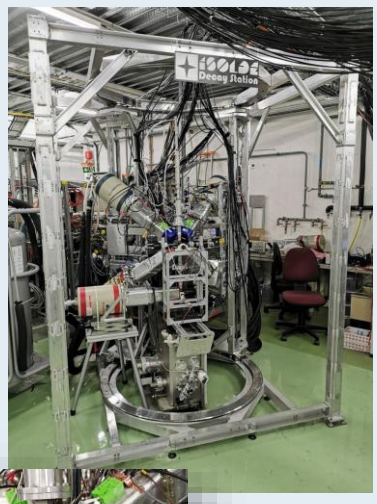
- 1.4 GeV p+ on ISOL target (Th Carbide)

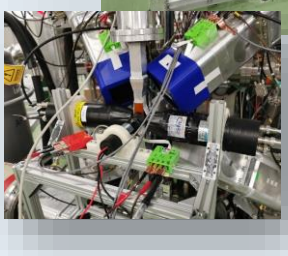


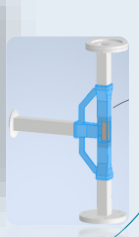


- After mass separation: ^{229}Fr, ^{229}Ra primary beam was stopped on the moving tape collector of IDS. The β-decay of ^{229}Ra was observed.

- *IDS Setup*:
  - 3 HPGe clovers
  - 3 scintillators for beta-tagging
  - 3 $LaBr_3$ detectors
  - Moving Tape Collector (T-piece)



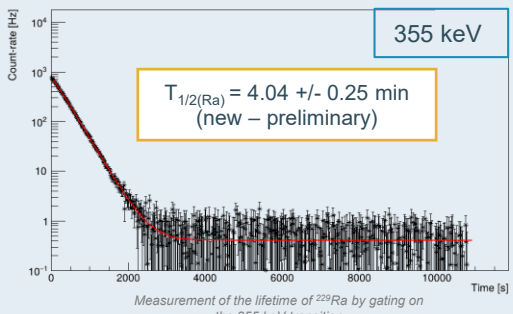




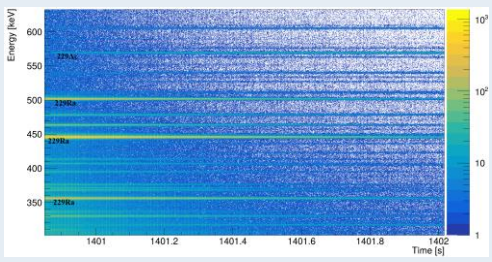
Preliminary Results

LIFETIME BEHAVIOUR

- By gating on different γ-rays it is possible to identify the isotope of interest and measure the lifetime of ^{229}Ra.



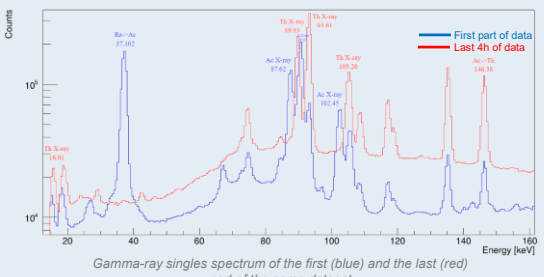
Measurement of the lifetime of ^{229}Ra by gating on the 355 keV transition



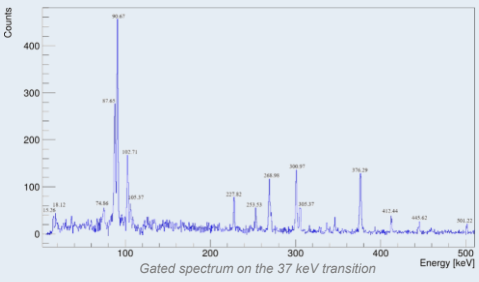
Energy vs. time for the total amount of data

COINCIDENCE GAMMA-SPECTROSCOPY ANALYSIS

- Coincidence analysis, addback correction, β-tagging, and comparing early vs. late data of the run reduces background, suppresses unwanted peaks and reveals weak or lifetime-dependent structures.



Gamma-ray singles spectrum of the first (blue) and the last (red) part of the same dataset



Gated spectrum on the 37 keV transition

PROPOSED ^{229}Ac LEVEL SCHEME

- The 1st excited state in ^{229}Ac is proposed to be at **37.1 keV**.

- New states are established with transitions to both the g.s and the 1st excited state.

Proposed level scheme of the β-decay of ^{229}Ra to ^{229}Ac

Future Directions

- Spectroscopy studies for the verification and extension of the decay scheme of ^{229}Ac are on-going.
- Calculation of the absolute γ-ray intensities and conversion coefficients [9].
- More precise re-definition of the $T_{1/2}$ of ^{229}Ra.

References

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[6] C. Zhang, T. Ooi, J. S. Higgins et al., Nature 633, 63–70 (2024).
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