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Lifetime measurements of 2^+_2 and 3^+_1 states in ^{20}O

GANIL spiral2
laboratoire commun CEA/DRF CNRS/IN2P3

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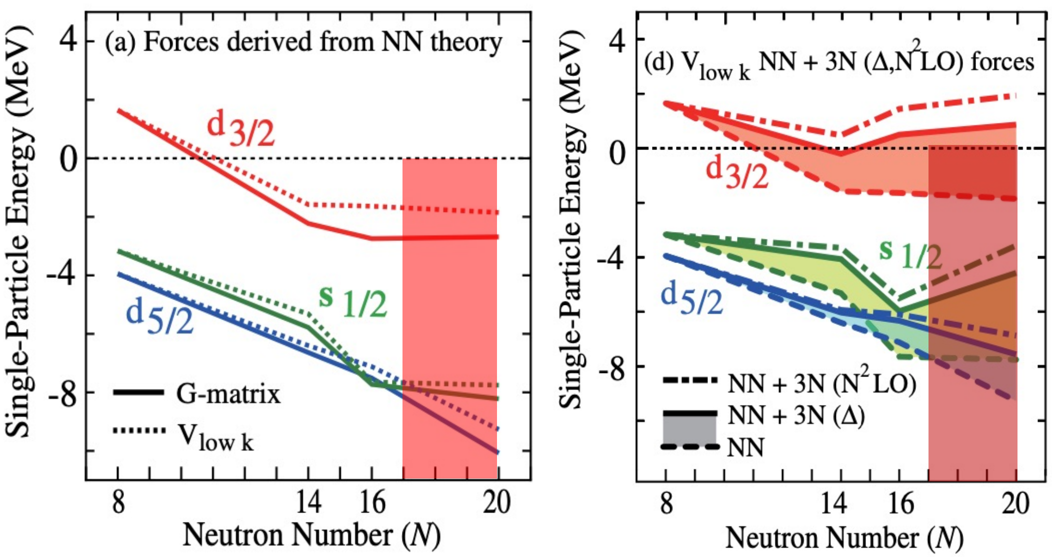
The role of 3N forces

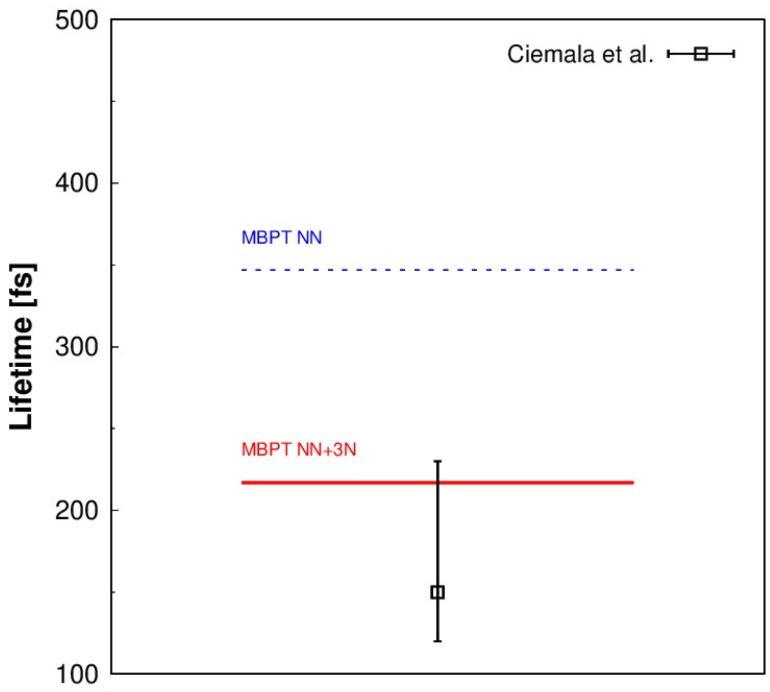
- Shell model calculations failed to reproduce the oxygen dripline.
- When adding the 3N forces, the dripline changes from the $0d_{3/2}$ orbital (N=20, ^{28}O) to the $1s_{1/2}$ (N=16, ^{24}O).
- Additional information on the relative position of the orbitals is need.



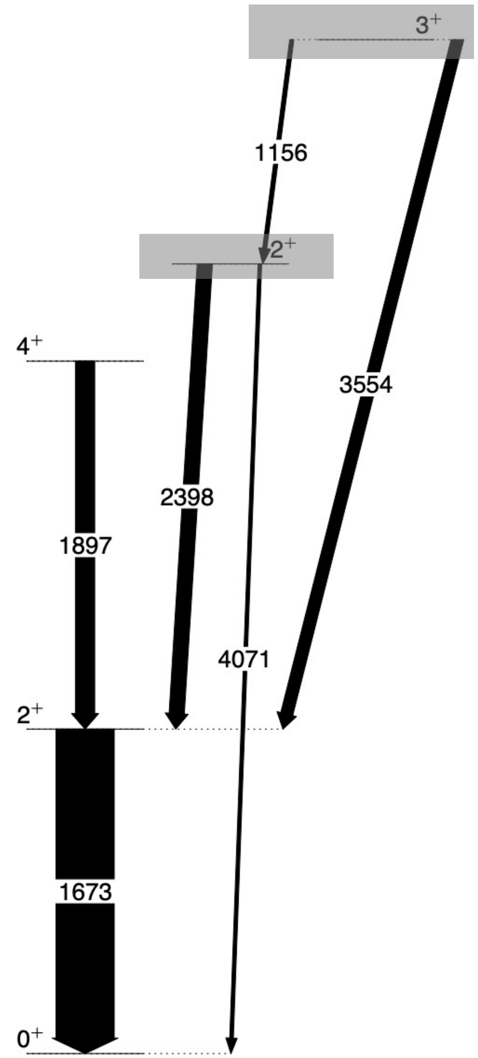
*T. Otsuka et al., PRL **104**, 012501 (2010)*

Non-yrast states in ^{20}O

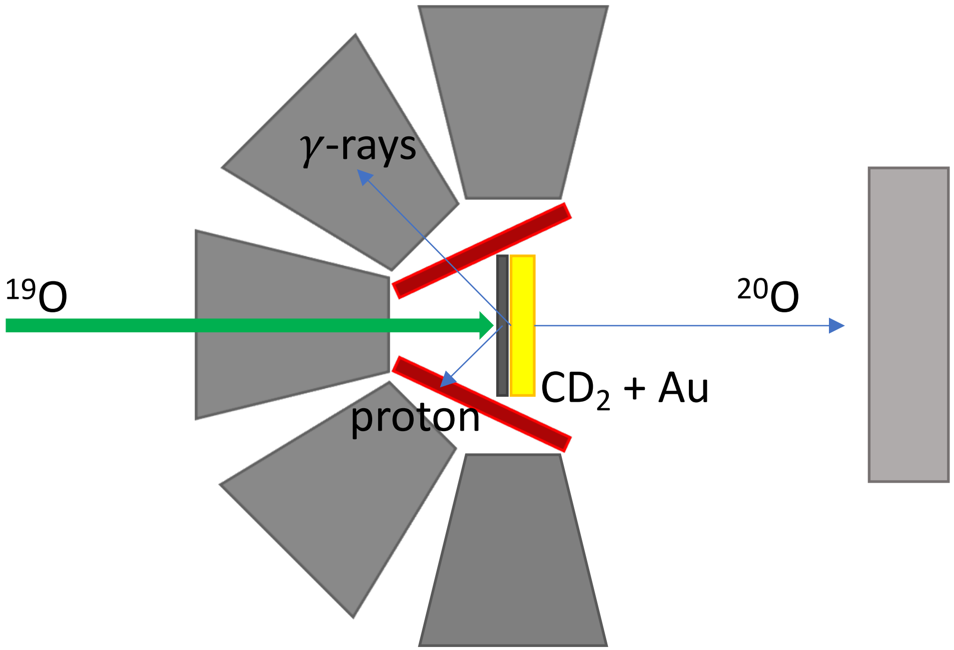
- The non-yrast states are sensitive to the position of the $0d_{3/2}$ orbital.
- The gap between the orbitals influences the lifetime of the 2^+_2 and 3^+_1 states of ^{20}O.



M. Ciemała et al, PRC ***101*** *021303 (2020)*



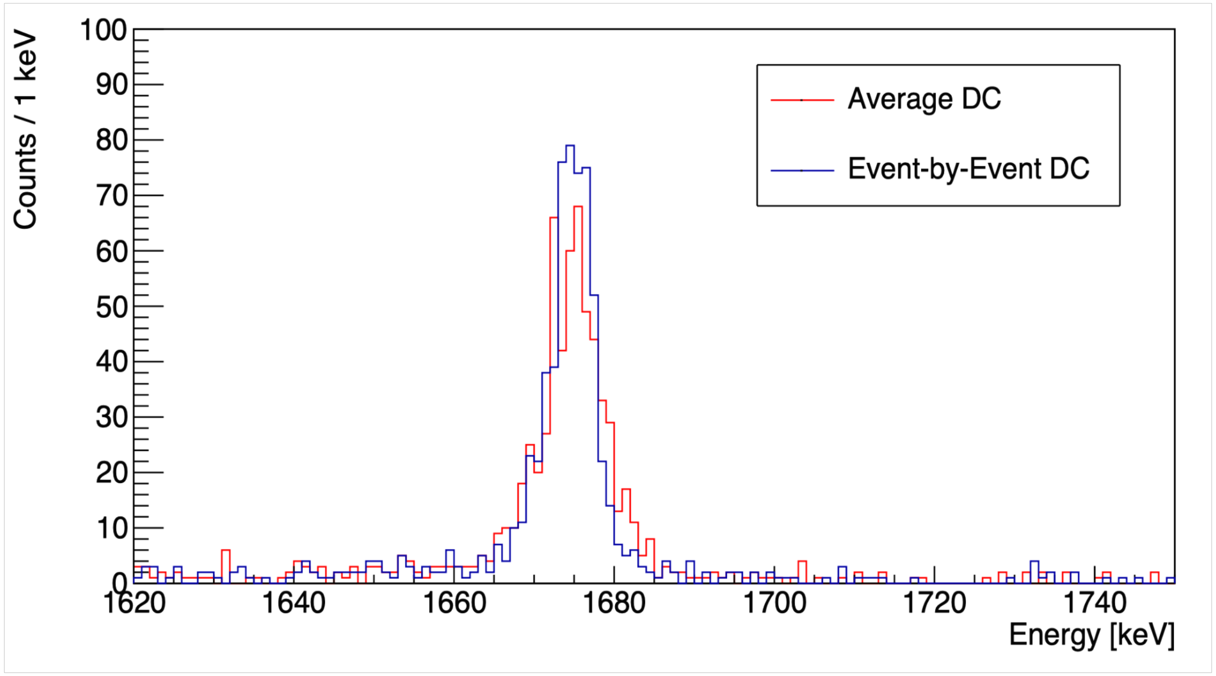
The experiment



- ^{19}O(d,p)^{20}O reaction
- Beam ^{19}O 8 MeV/A
  i: $4x10^5$ pps.
- Target CD_2 0.3 mg/cm^2
  + ^{nat}Au 20 mg/cm^2.
- AGATA array +
  MUGAST + VAMOS.

Event-by-event Doppler correction

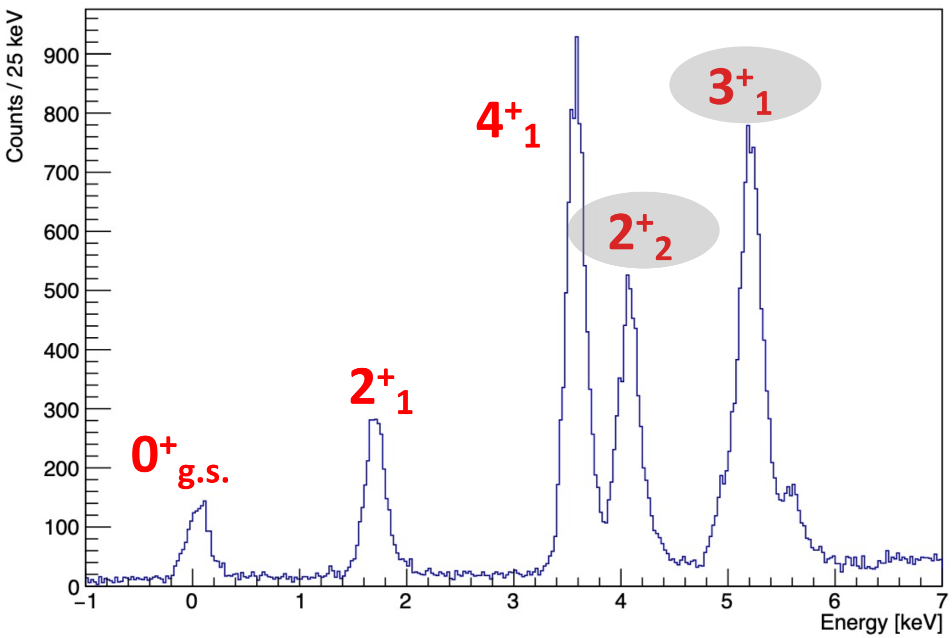
The velocity vector and excitation energy of the ^{20}O recoil was reconstructed from the information on the proton.

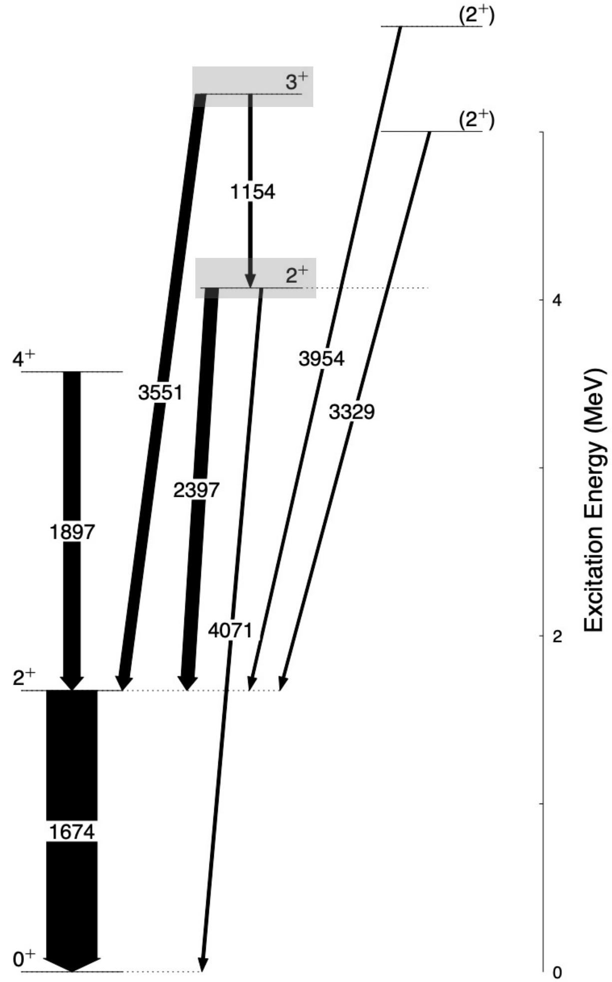


The event-by-event Doppler correction improved the resolution of 25% with respect to the one using the average β=12.6%

The experiment

By gating on the excitation energy spectrum, it was possible to reconstruct the level scheme of the ^{20}O nucleus.





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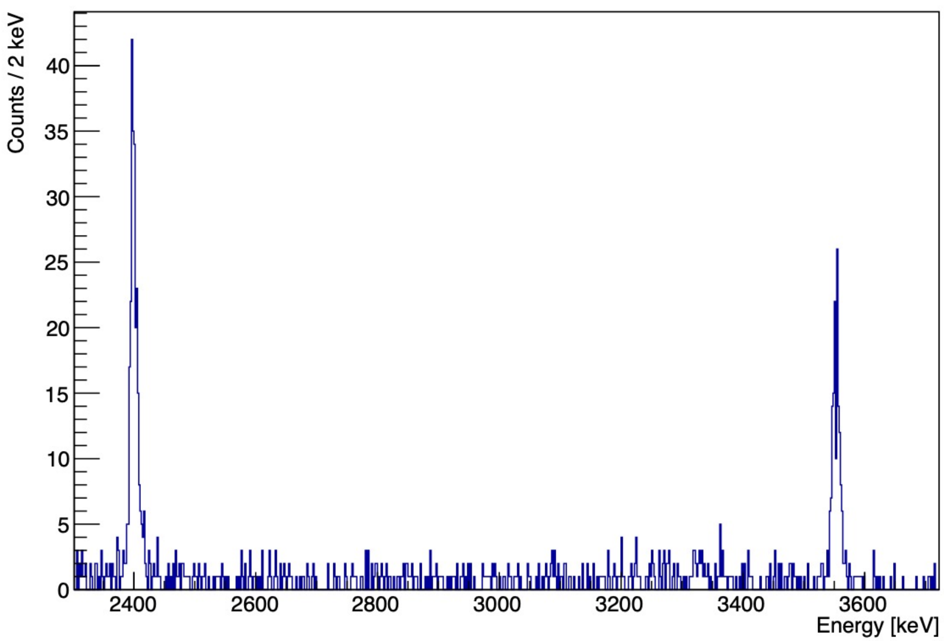

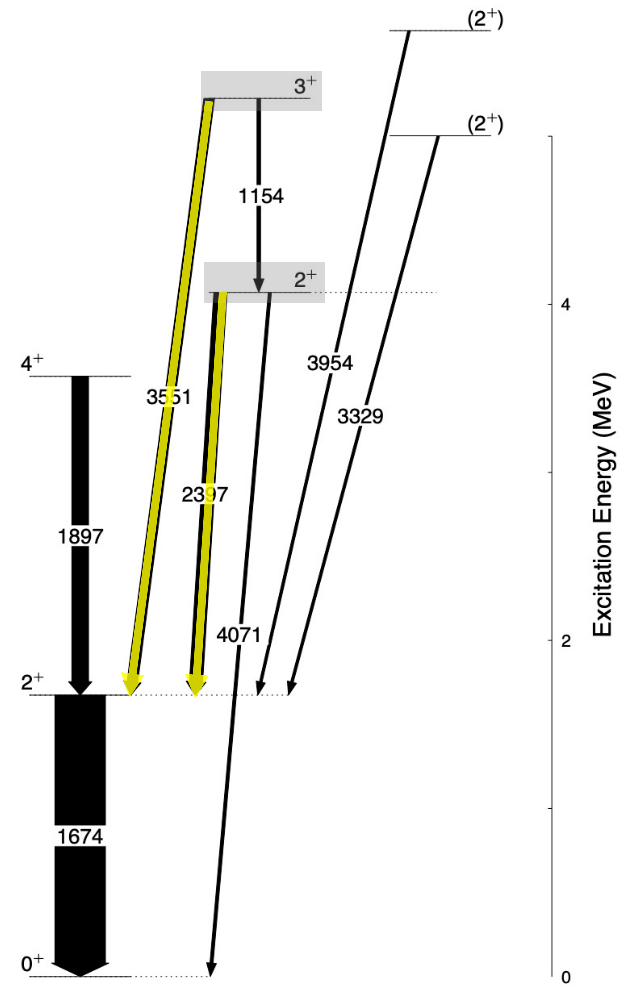

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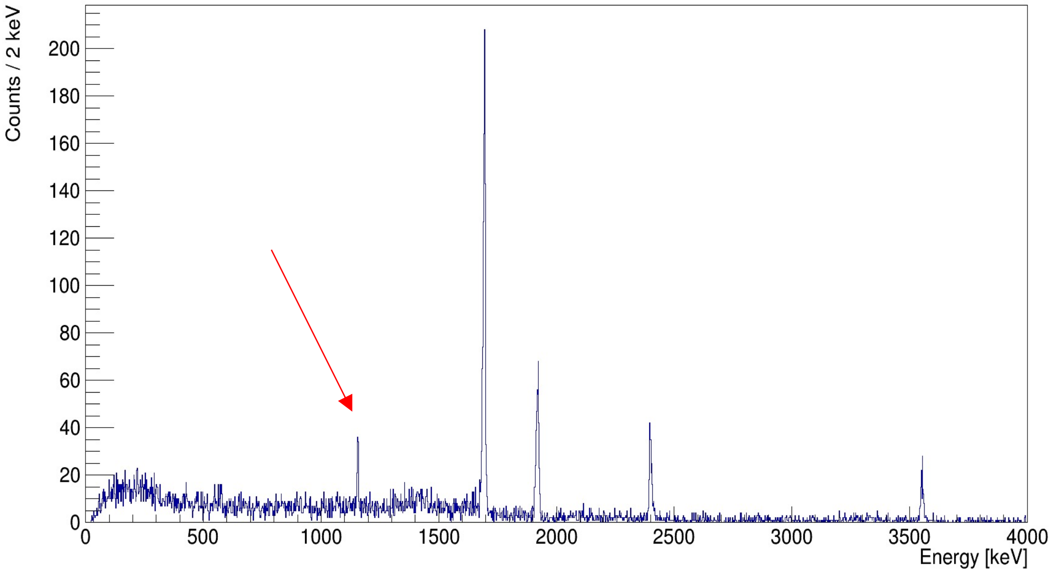
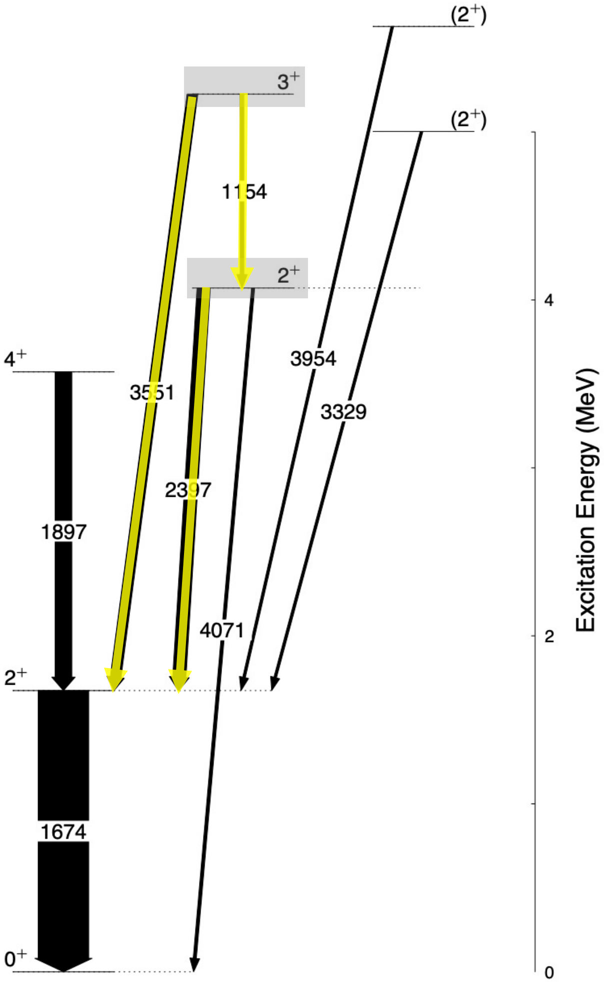
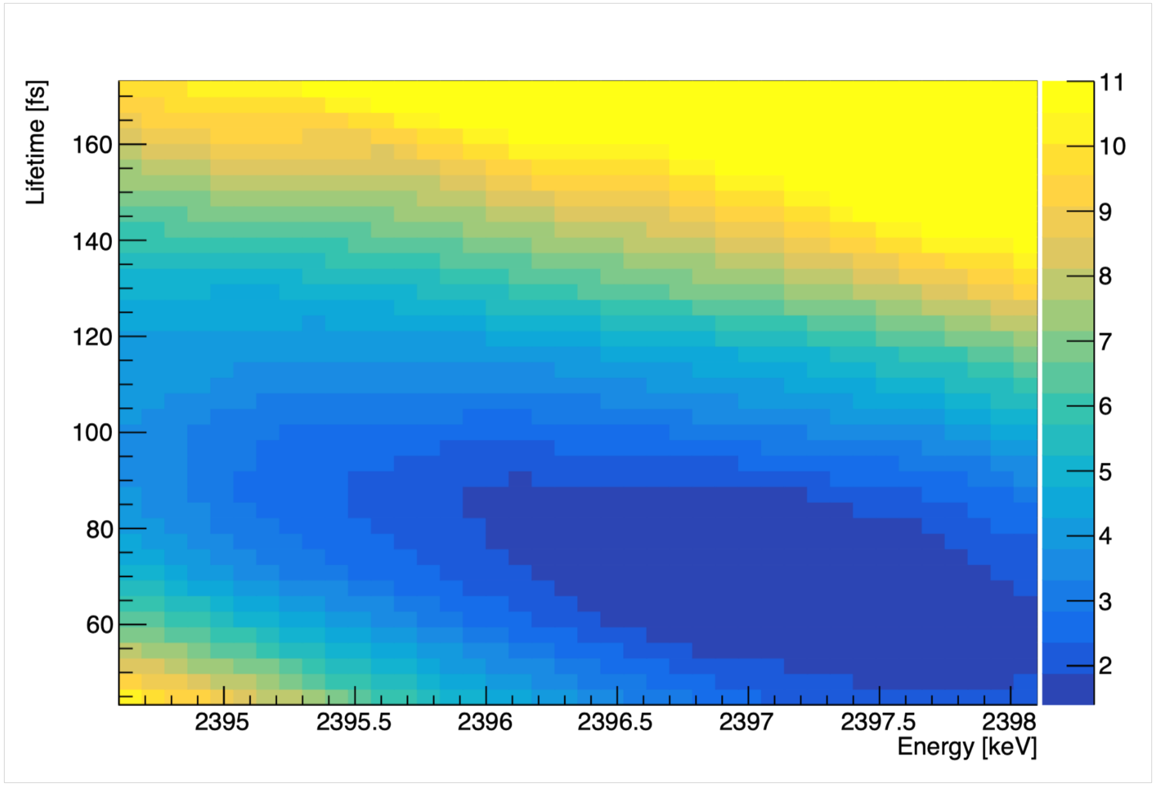




Lifetime measurement of the 2^+_2 and 3^+_1

The lifetime measurement is extracted by comparing the lineshape of the transition to Monte Carlo simulations performed with Geant4.

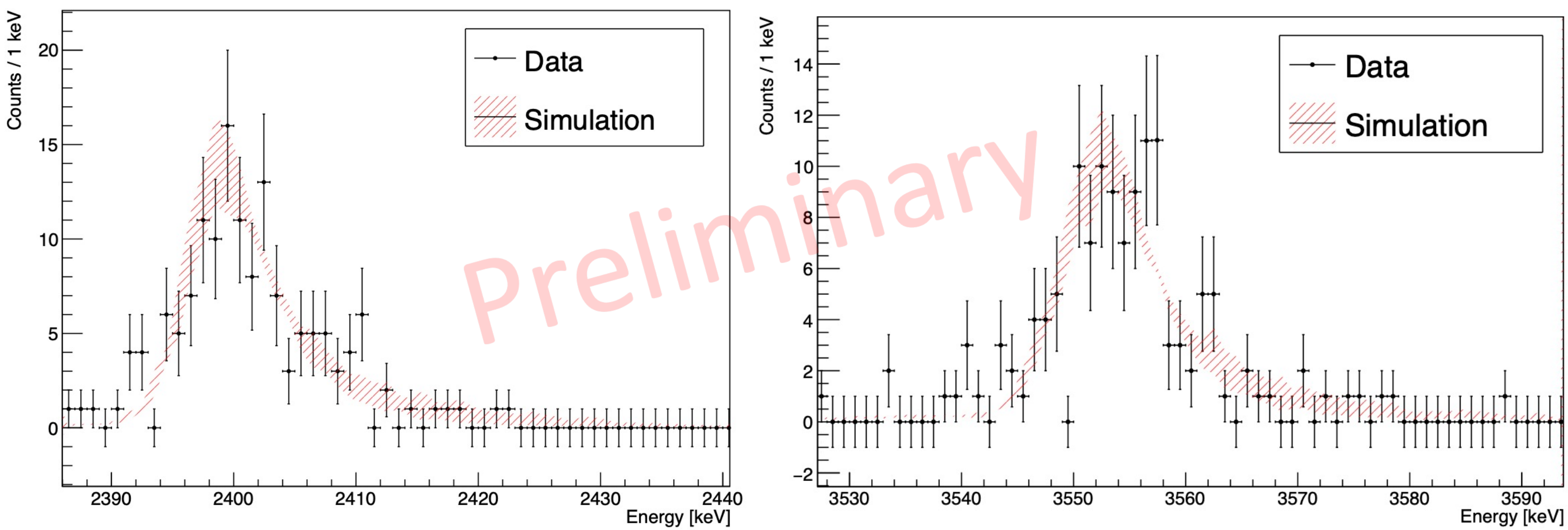


Realistic parameters like angular distributions and resolutions of HPGe detectors are added to the simulation.

The experimental and simulated spectra are compared using the least-χ^2 test.

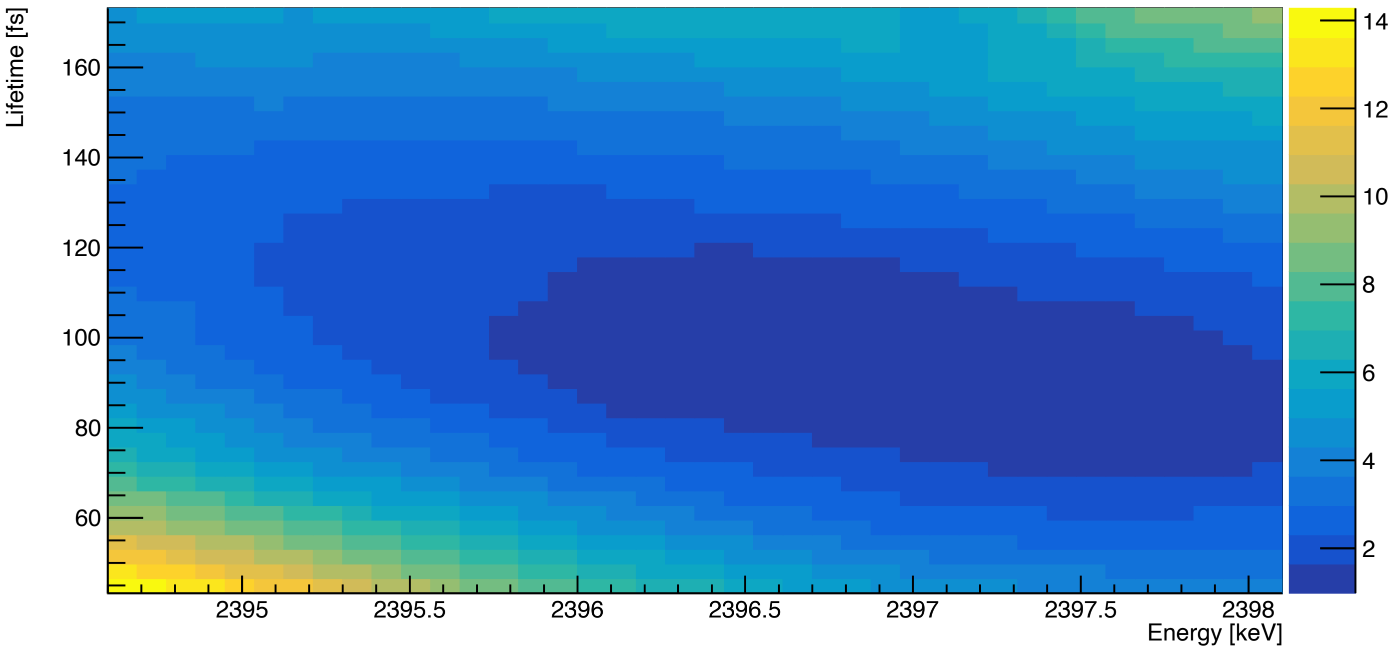
Lifetime measurement of the 2^+_2 and 3^+_1

- The lifetime of the 2^+_2 resulted to be 63^{+29}_{-16} fs.
- The lifetime of the 3^+_1 resulted to be 55^{+16}_{-19} fs.
- Systematic errors are still being evaluated.

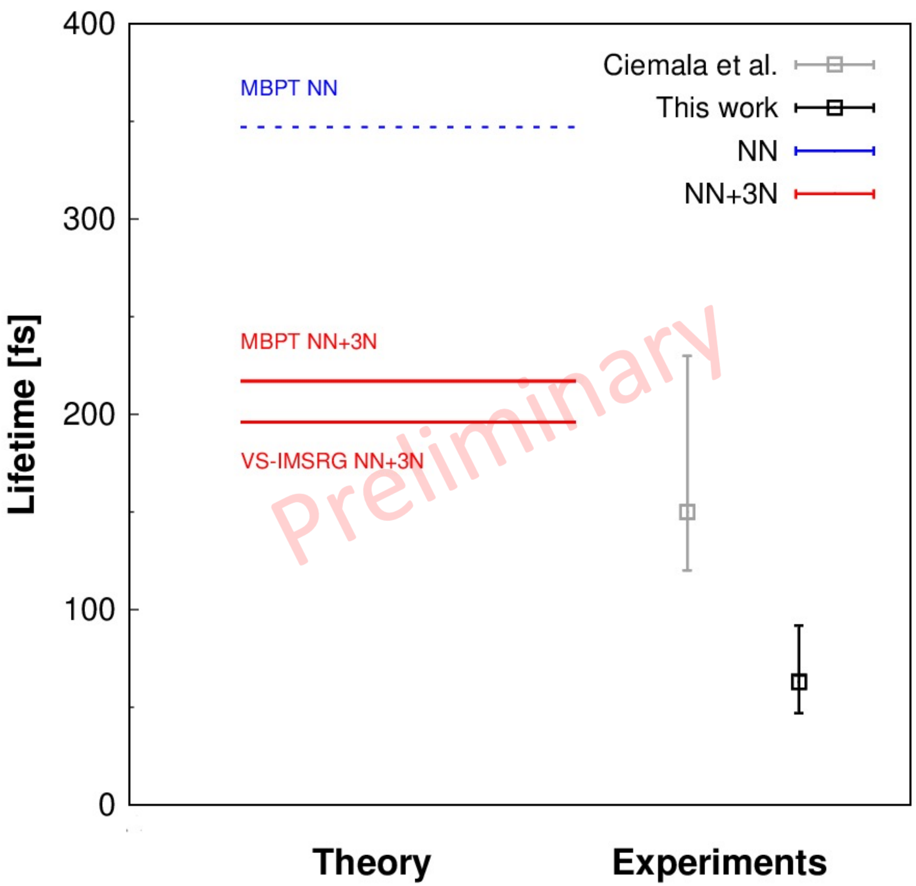


Influence of the feeder

Without the gate on the direct population of the 2^+_2, the lifetime of the state results to be about 40% longer.



Theoretical calculations



*M. Ciemała et al, PRC **101** 021303 (2020)*

The new experimental value of the 2^+_2 confirms the influence of 3N forces in this region.

The discrepancy of this new measurement leaves open questions.

Conclusions

- Challenging experiment with state-of-the art particle detection and γ-ray tracking;
- Strong control on the population of the states using of (d,p) reaction to populate the ^{20}O nucleus;
- Lifetime measurement of the 2^+_2 and 3^+_1 states;
- Evidence of the role of 3N forces in the ab-initio calculations.

Thanks to the collaboration

I. Zanon, E. Clément, A. Goasduff, M. Ciemała, M. Assié, F. Flavigny, C. Fougeres, S. Leblond, A. Lemasson, A. Matta, D. Ramos, K. Rezynkina, M. Rejmund, M. Siciliano.
D. Ackermann, D. Beaumel, S. Bottoni, D. Brugnara, N. de Sereville, F. Delauney, F. Didierjean, G. De France, P. Delahaye, J. Dudouet, D. Fernández Fernández, J.L. Fuentes, A.F. Gadea Raga, F. Galtarossa, V. Girard-Alcindor, F. Hammache, A. Kosoglu, C. Lenain, J. Ljungvall, A. Lopez-Martens, G. Pasqualato, D. Ragueira Castro, J.S. Rojo, A. Utepov, Y.H. Kim, M. Zielinska

On behalf of the AGATA, VAMOS and MUGAST collaborations

AGATA ADVANCED GAMMA TRACKING ARRAY

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nptool

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