Searching for low-energy shape coexistence in ^{80}Ge

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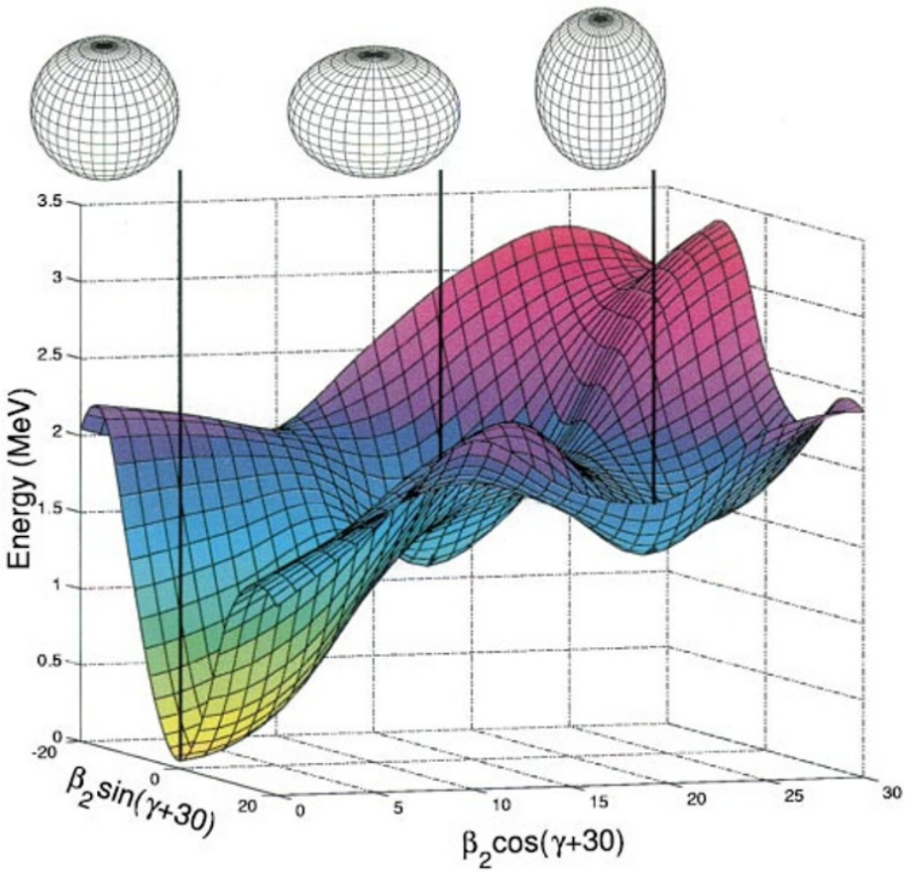
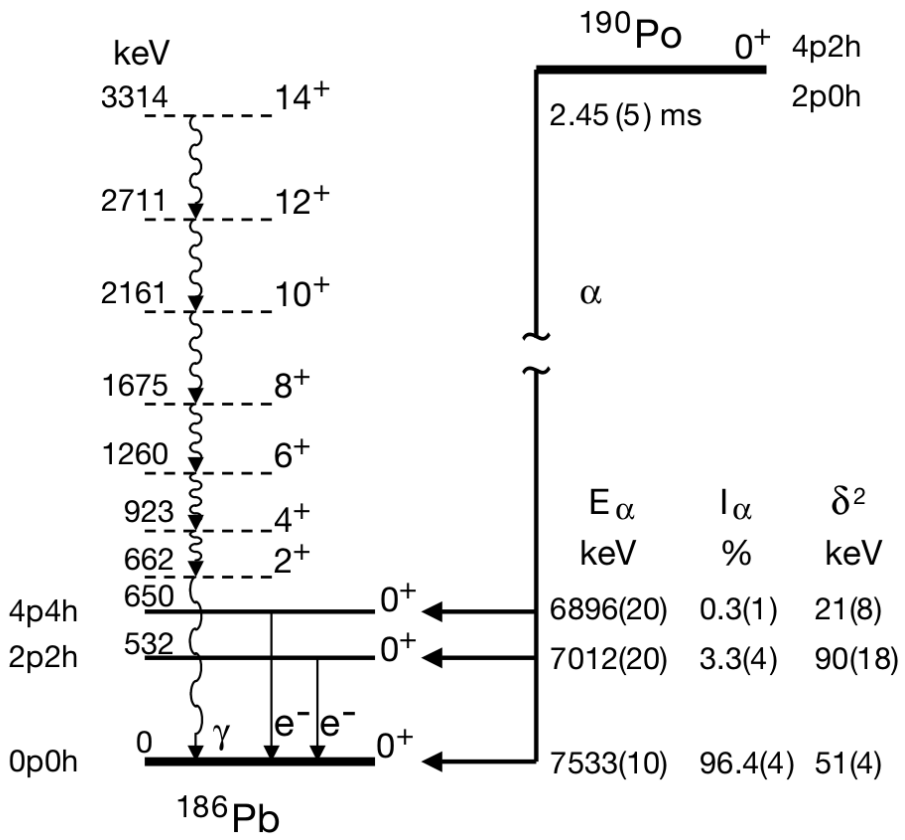
Shape coexistence

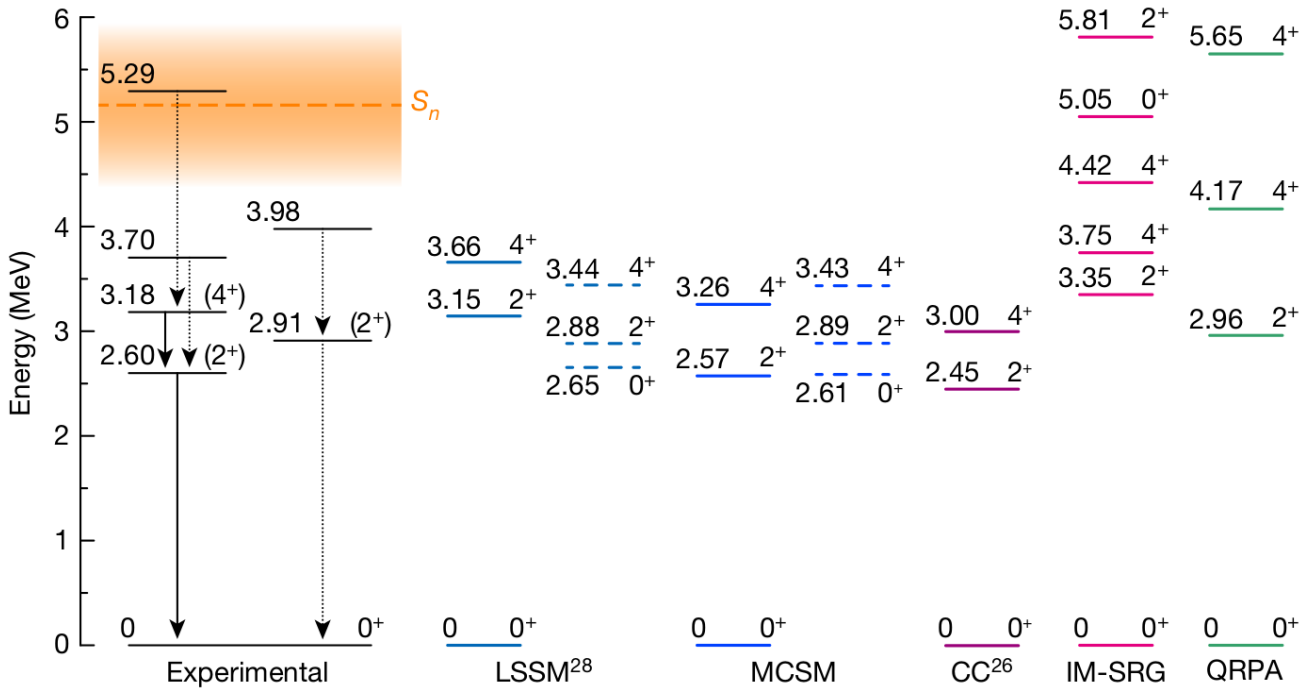




Andreyev *et al.*, *Nature* 403, 430 (2000)

^{78}Ni: evidence for shape coexistence

A recent experiment probed the structure of doubly magic ^{78}Ni.

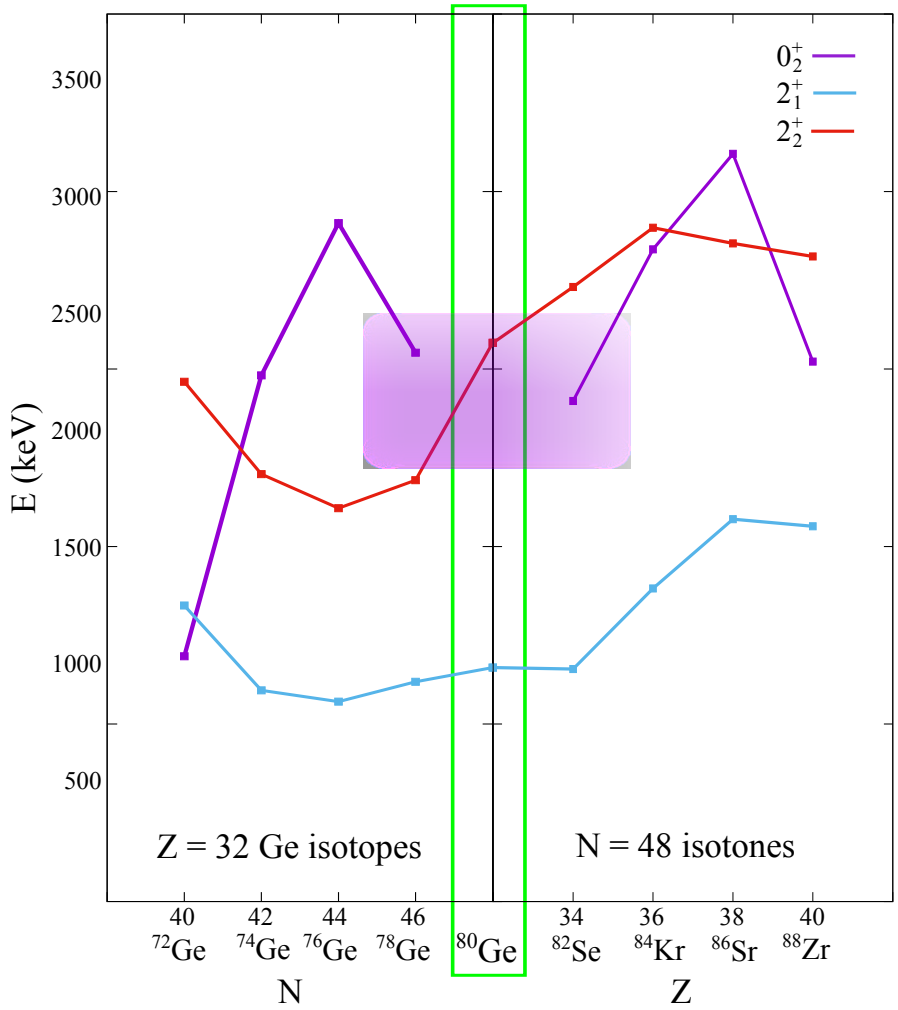


An excited 2^+ state was observed at only 0.31 MeV above the 2_1^+, suggesting shape coexistence in this nucleus.

Taniuchi, R. *et al.*, *Nature* 569 (2019) 53

Coexistence in neighbouring nuclei

^{78}Ni is proposed to be a portal to the fifth island of inversion*.



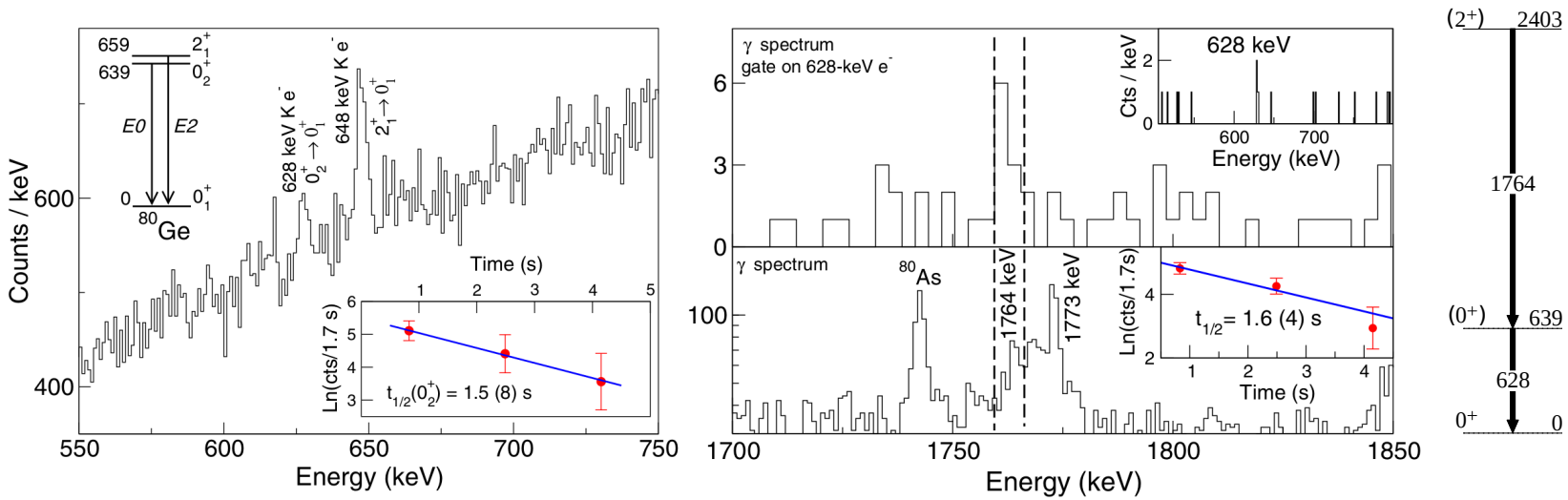
NNDC, Brookhaven National Laboratory

*Nowacki, F., Poves, A., Caurier, E. and Bounthong, B., *PRL* 117, 272501 (2016)

Low-lying Coexistence in ^{80}Ge

An ALTO experiment observed a state 0_2^+ state in ^{80}Ge at 639 keV, through a conversion electron peak at 628 keV.

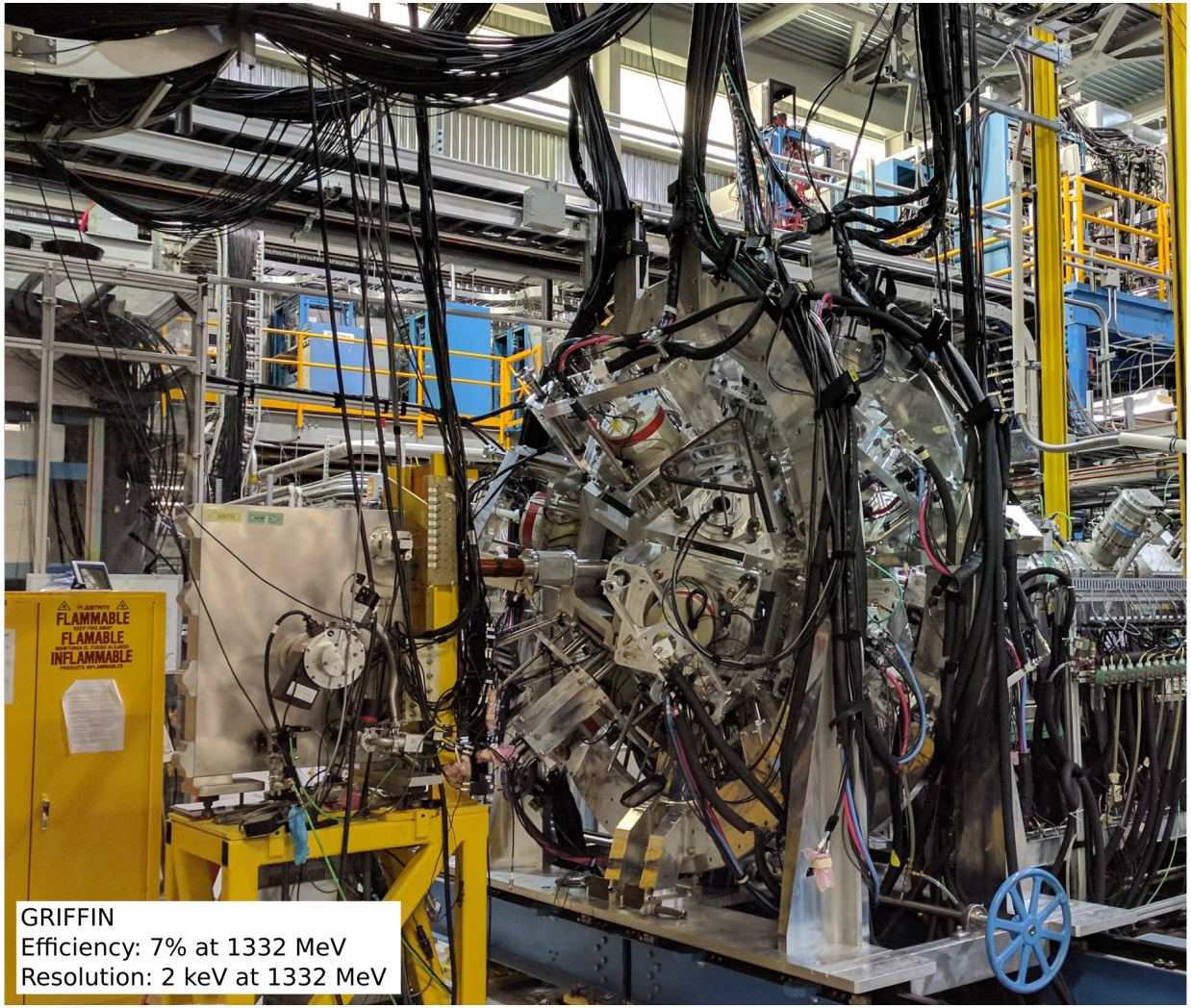
A coincidence was also observed between the 628-keV conversion electron peak and a 1764-keV γ-ray, from a proposed 2403 keV state.

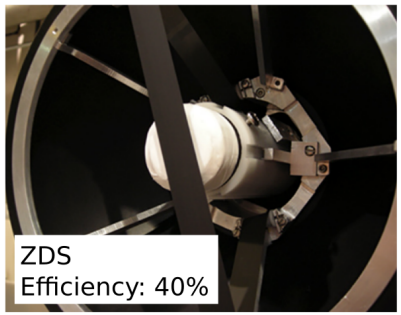


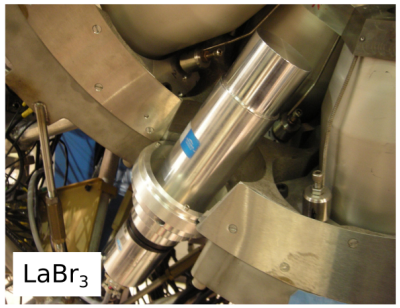
The binding electron of the K-shell electron in ^{80}Ge is 11 keV

Gottardo, A. *et al.*, *PRL* 116, 182501 (2016)

GRIFFIN for β-decay spectroscopy





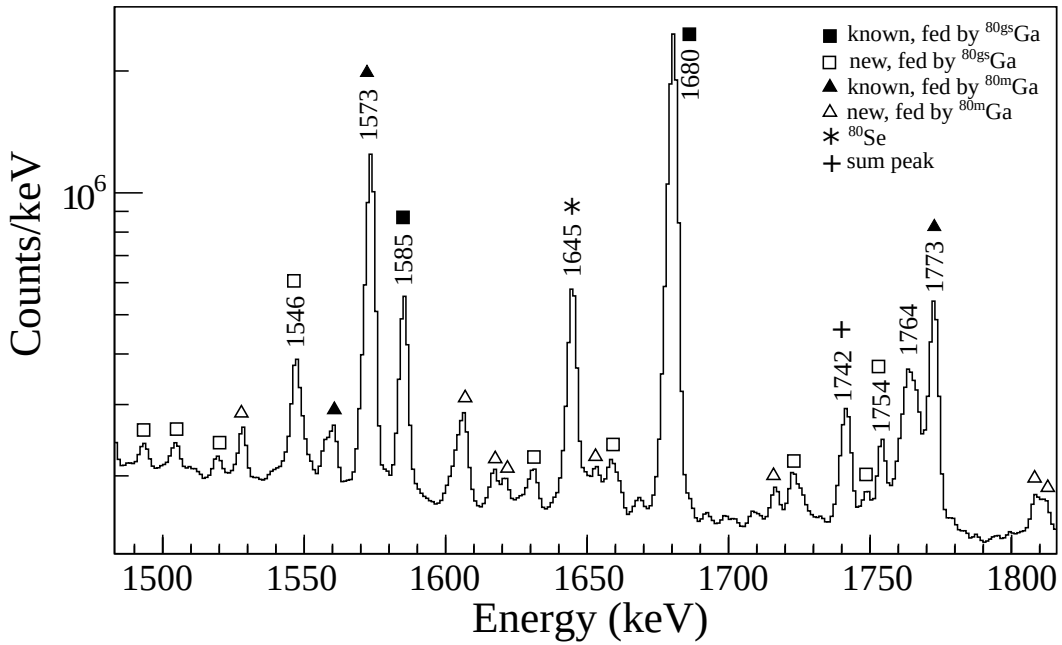


Garnsworthy, A. B. *et al.*, *NIM A* 918,9 (2019)

Quality of the dataset

Experimental details:

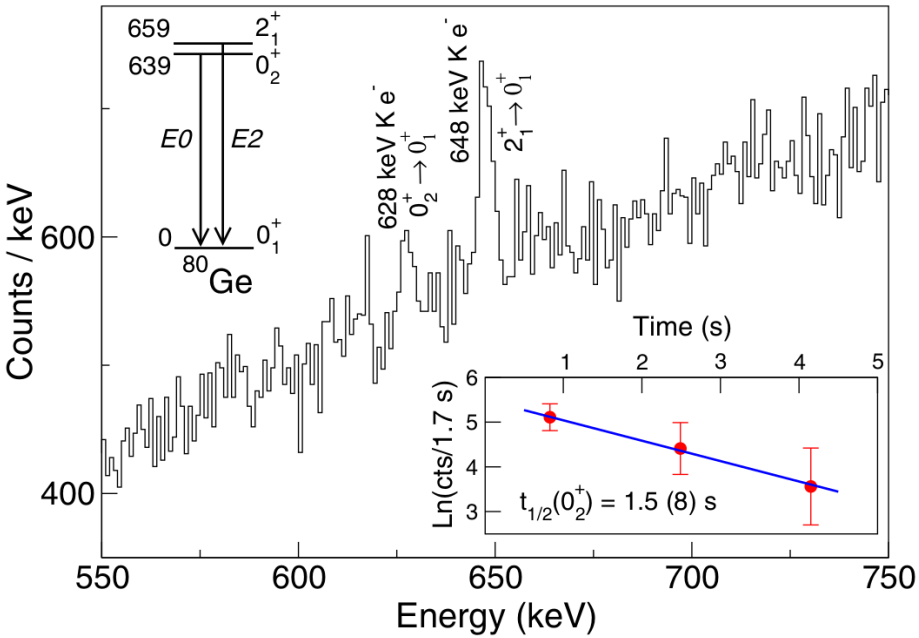
- ^{80}Ga β-decay to ^{80}Ge
- Run time: 51 hrs
- 78% ^{80}Rb contaminant
- 22% ^{80}Ga at 2×10^4 pps
- 6^- ^{80gs}Ga: 53%
- 3^- ^{80m}Ga: 46%

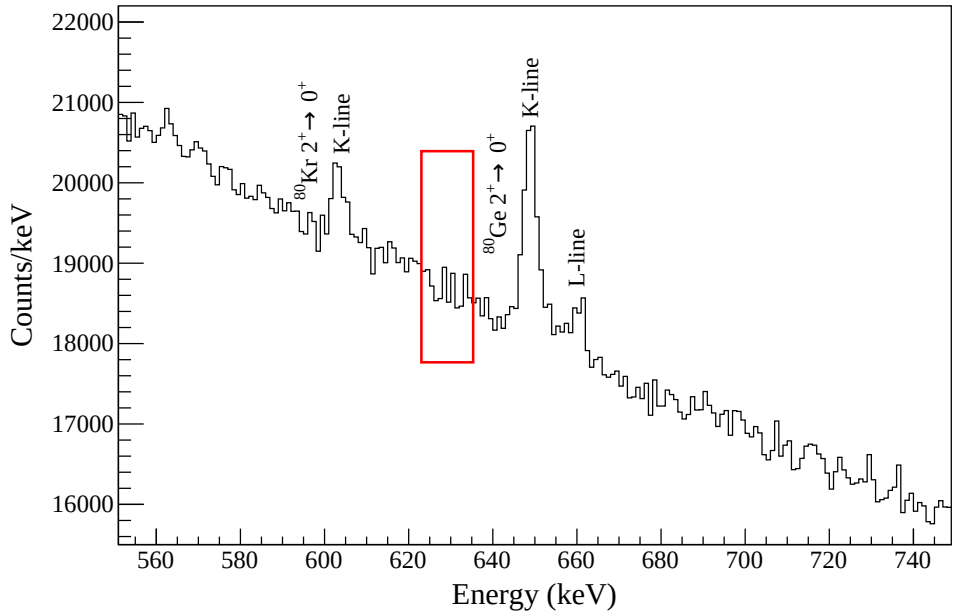


Garcia, F. H. *et al.*, *PRL* 125, 172501 (2020)

Contradictory Results

The GRIFFIN experiment used PACES for conversion electron detection.





ALTO I^{628}: $\sim$0.08%

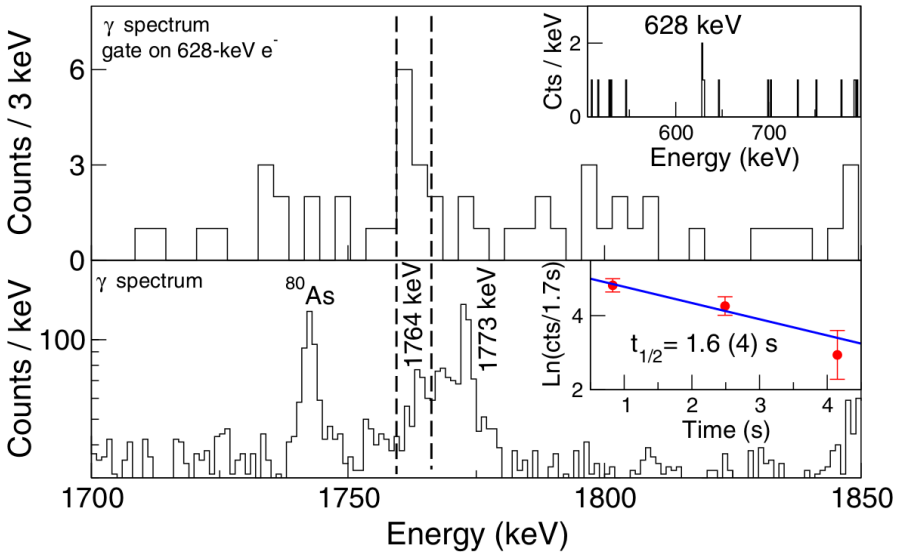
GRIFFIN 2σ limit: $<$0.02%

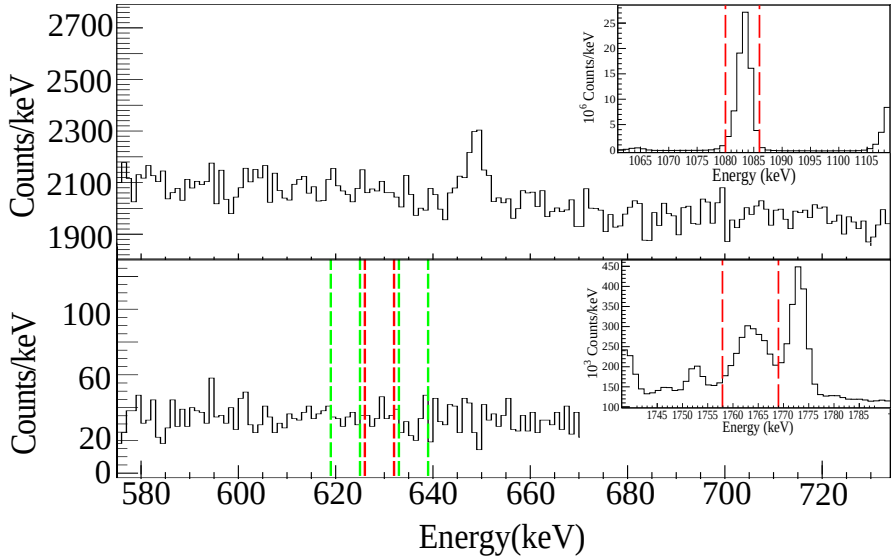
Gottardo, A. *et al.*, *PRL* 116, 182501 (2016)

Garcia, F. H. *et al.*, *PRL* 125, 172501 (2020)

Searching for transitions

Limits were calculated to determine detection sensitivity.





ALTO I_{1764}/I_{1772}: 0.3

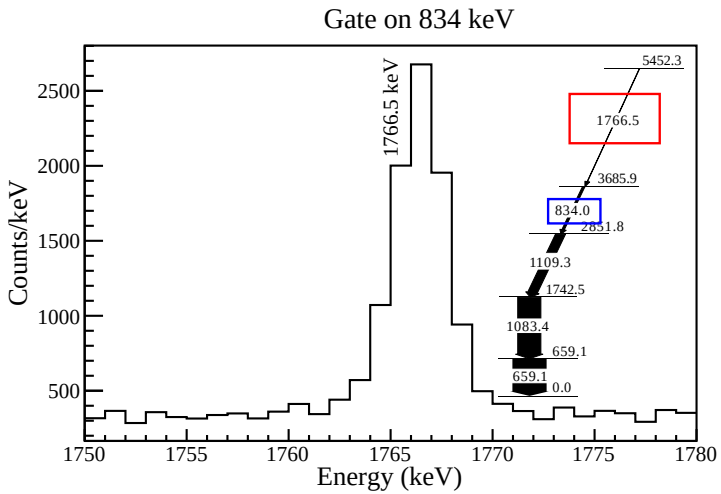
GRIFFIN I_{1764}/I_{1772} 2σ limit: 0.003

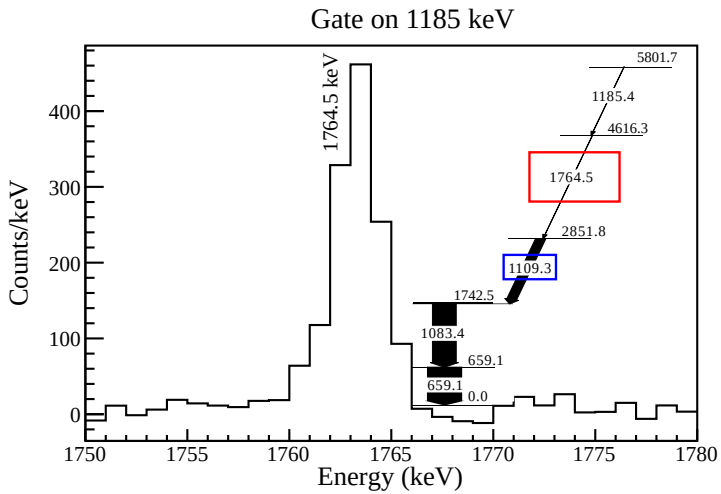
Gottardo, A. *et al.*, *PRL* 116, 182501 (2016)

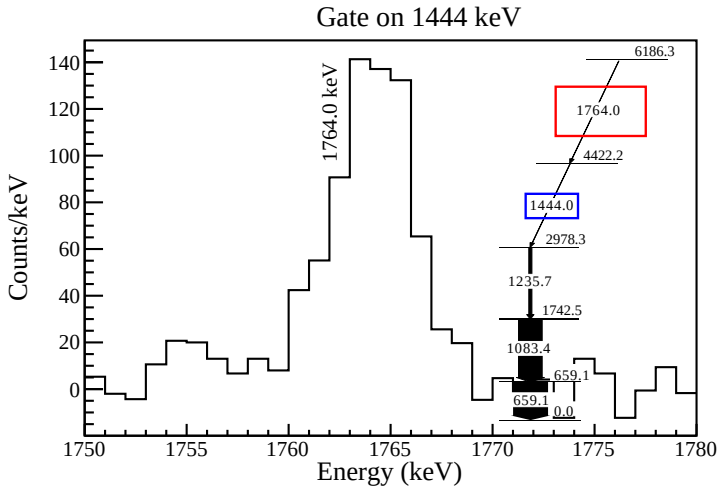
Garcia, F. H. *et al.*, *PRL* 125, 172501 (2020)

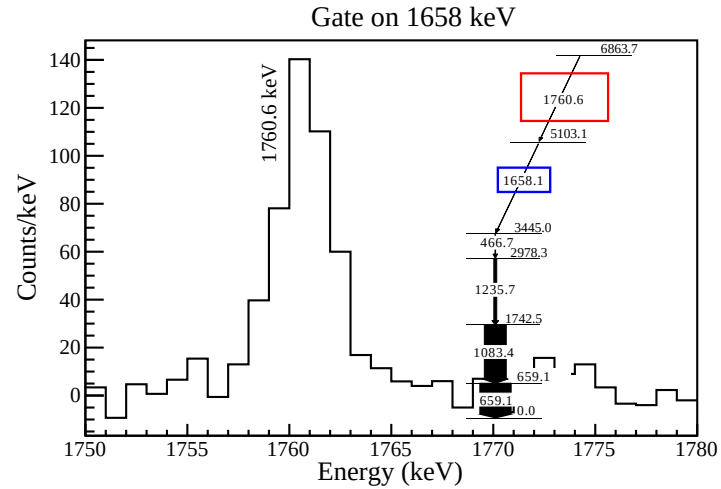
1764-keV γ-ray

The broad peak at 1764 keV is in fact four different transitions (red), observed in different gates (blue);



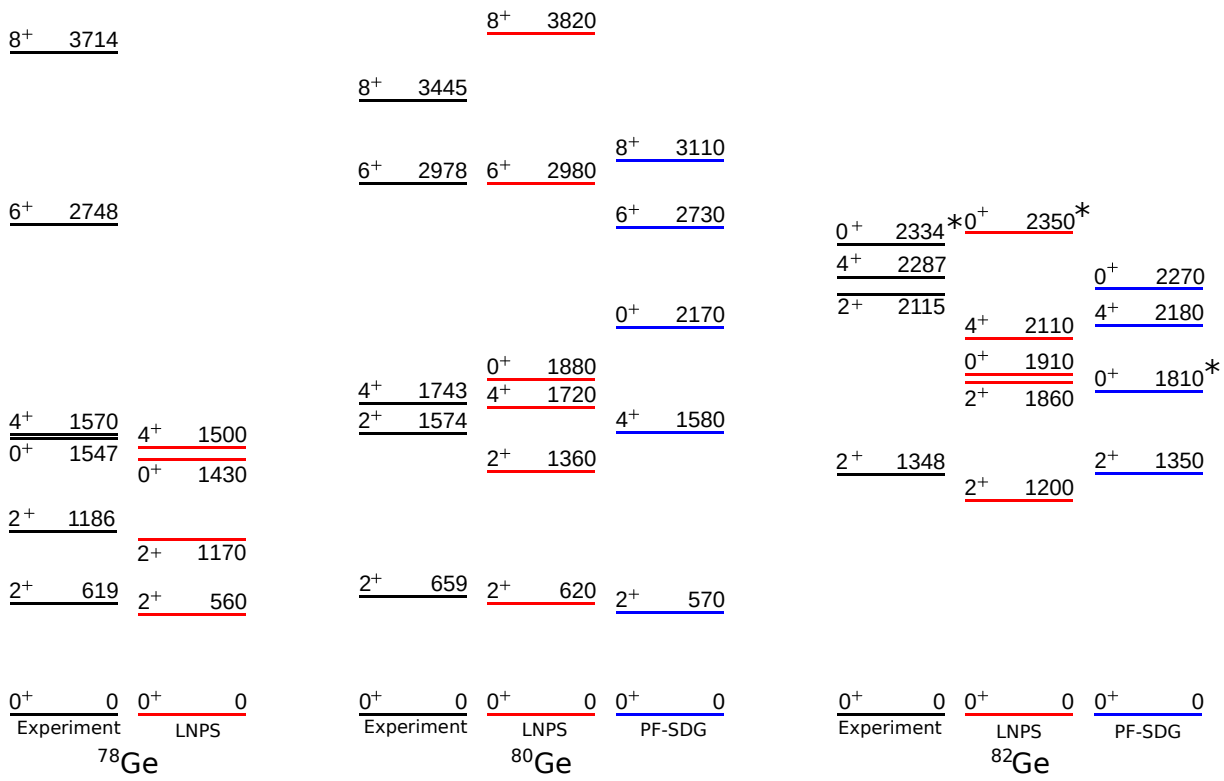






Theoretical considerations

Large-scale shell model calculations were performed, and were able to reasonably predict intruder configurations in neighbouring isotopes.



Garcia, F. H. *et al.*, *PRL* 125, 172501 (2020)

Lenzi, S., Nowacki, F. Poves, A. and Sieja, K. *PRC* 82, 054301 (2010)

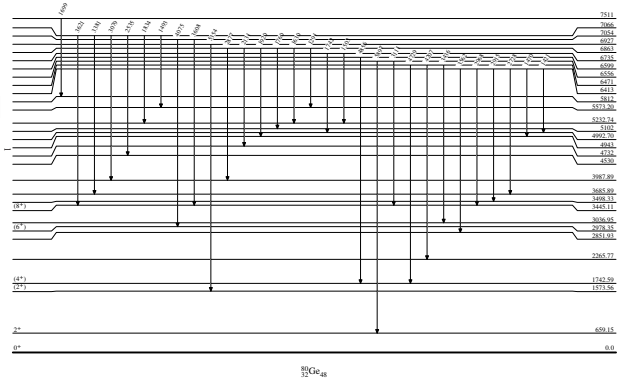
Nowacki, F., Poves, A., Caurier, E. and Bounthong, B., *PRL* 117, 272501 (2016)

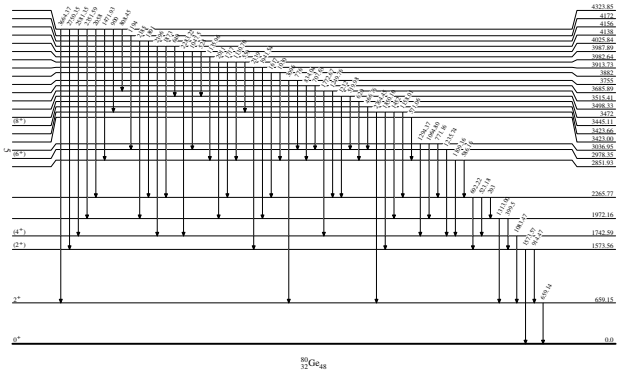
Current status and the future of ^{80}Ge data

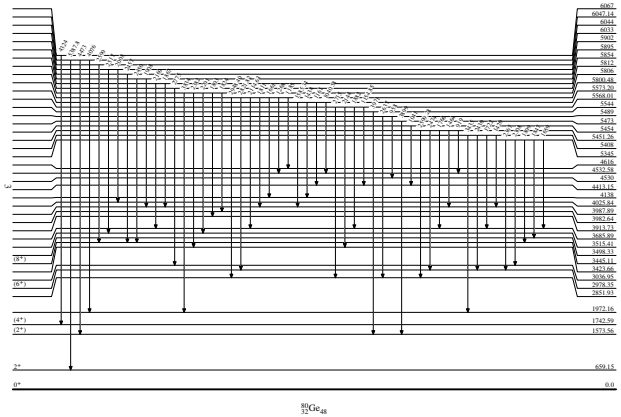
Analysis is still ongoing. The dataset is quite rich.

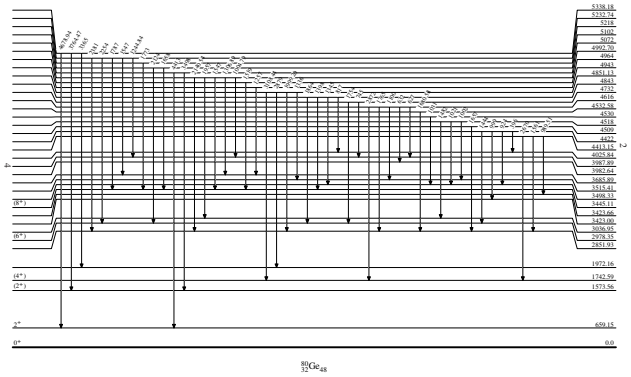
Highlights:
- ~77 newly observed transitions
- 10 previously observed transitions placed
- ~41 newly observed excited states

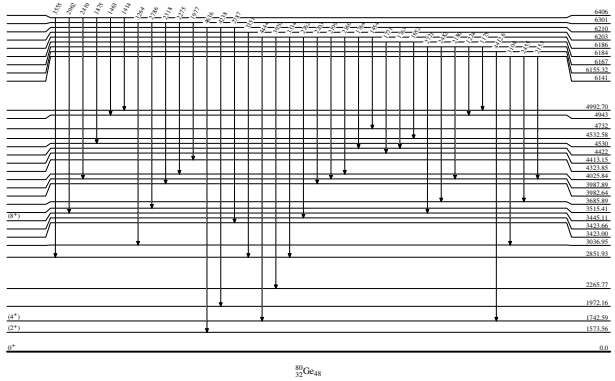
Next steps:
- β-feeding analysis for tentative spins
- Angular correlations for spin assignment
- Lifetime measurements of the 2^+ and 4^+











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University of Kentucky
E. E. Peters

Thank you

^{80}Ge experiment comparisons

GRIFFIN

- ISOL: p^+ reactions
- Yield: 2.4×10^4 pps
- ^{80gs}Ge: 53% / ^{80m}Ge: 46%
- 15 HPGe
- ϵ (1.3 MeV): 8%
- 5 Si(Li)
- 10 plastic scintillators

Gottardo *et al.*

- Photofission
- Yield: $\sim 10^4$ pps
- 1 HPGe
- ϵ (1.3 MeV): 0.7%
- 1 Si(Li)
- 1 plastic scintillator

Verney *et al.*

- Photofission
- Yield: 9.4×10^3 pps
- ^{80gs}Ge: 48% / ^{80m}Ge: 52%
- 2 HPGe
- ϵ (1.3 MeV): 1.4%

Isomeric Component calculation - I

A major concern that presented itself during the analysis was the quantity of each of the ground state and isomer of ^{80}Ge in the beam.

The $6(^-)$ g.s. and 22.4 keV $3(^-)$ isomer in ^{80}Ga are known to β-decay. ENSDF only shows the $3(^-)$ isomer β-decaying, but there is a high lying (8^+) in ^{80}Ge that has a non-zero β-feeding intensity. This can only be fed by the ground state in ^{80}Ga.

Isomeric Component calculation - II

To prove we had a comparable isomeric mixture, we chose two independent states to examine:

- (2^+) 1573-keV state fed only by the $3(^-)$ ^{80m1}Ga
- (8^+) 3445-keV state fed only by the $6(^-)$ ^{80gs}Ga

We compared the β-feeding intensities in our experiment and those in ENSDF and discovered a decrease of 0.66 in feeding of the 1573-keV state and an increase of 1.55 to the 3445-keV state.

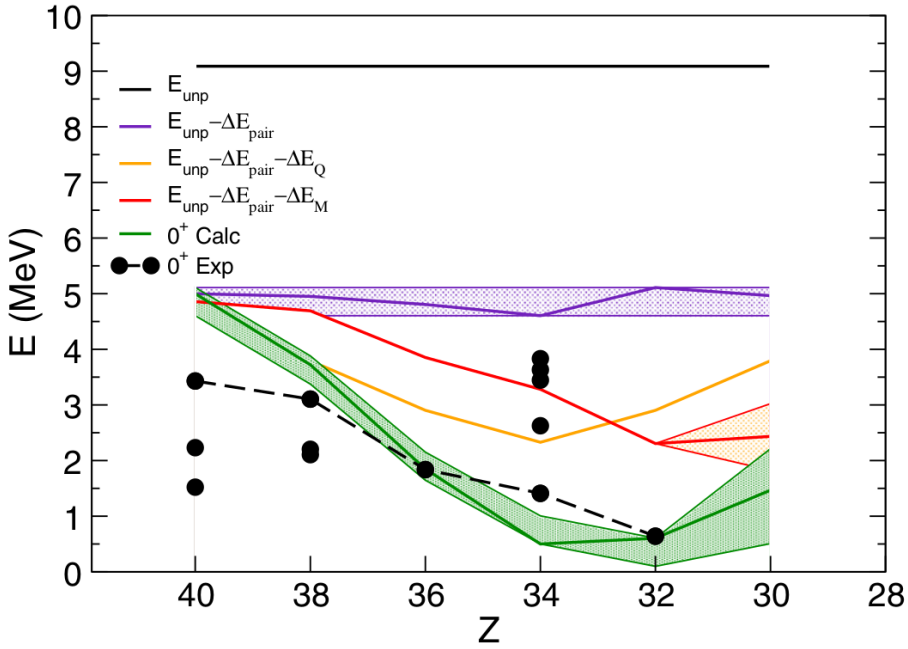
Given the ENSDF set contains a beam composition of 62% of the (3^-) isomer, we calculate a value of 41% of the same component.

Based on the data in the paper, ALTO observed 52% of ^{80m1}Ga in their beam.

Theoretical Interpretation - ALTO

The authors also employed theoretical models to show lowering of the 0_2^+ in context of different energy contributions.

The theoretically calculated value was in good agreement with their experimentally observed value.



Gottardo, A. *et al.*, *PRL* 116, 182501 (2016)