

Search for tetrahedral shape
around ^{110}Zr and possible shell
closure at $N=70$

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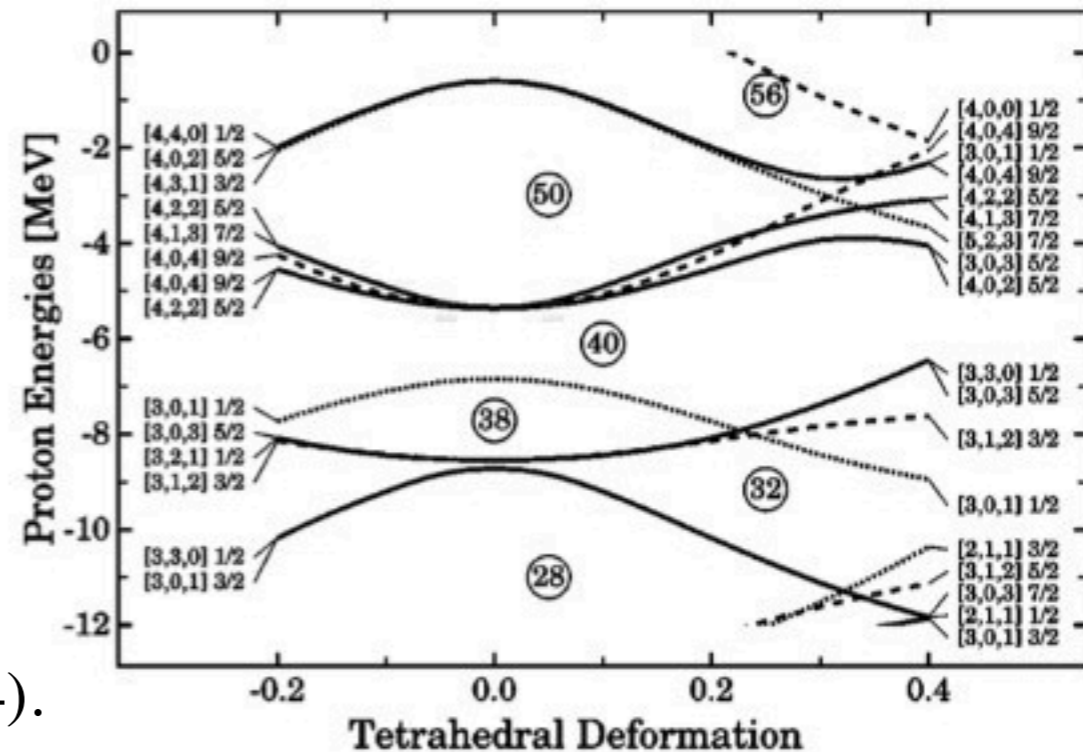
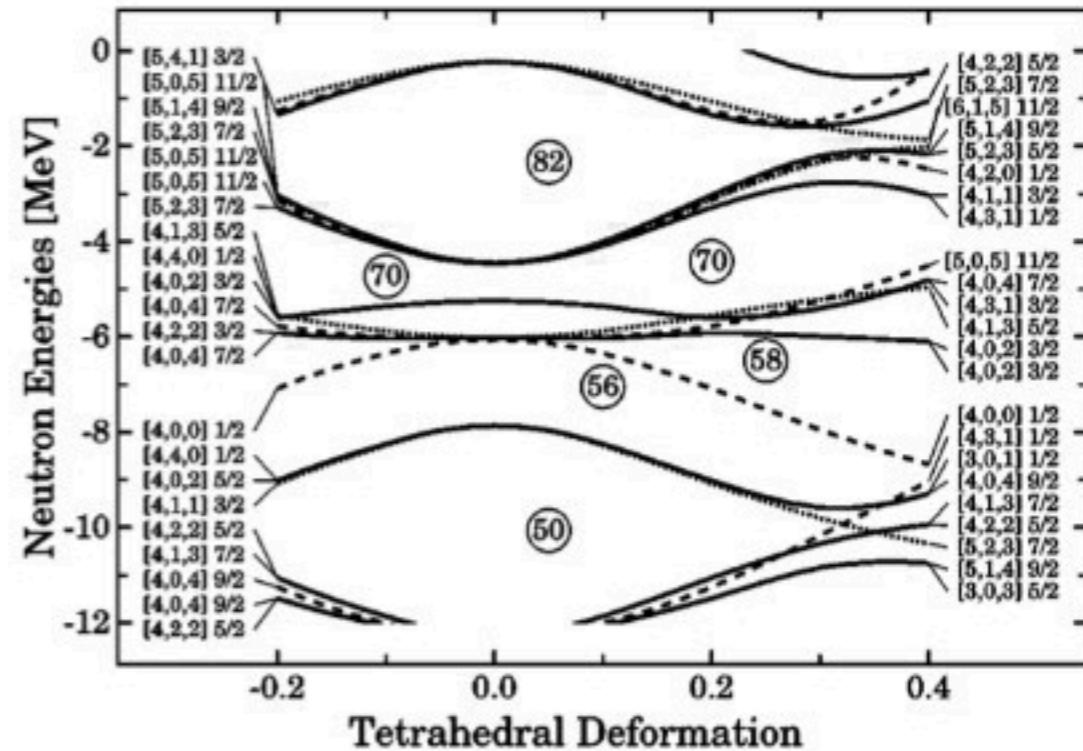
- ✿ Introduction: Structural evolution of Zr isotopes
- ✿ Decay spectroscopy for $^{106,108}\text{Zr}$ performed at RIBF
- ✿ Decay Spectroscopy around ^{108}Zr with EURICA
- ✿ Summary

SYMMETRY OF TETRAHEDRAL SHAPE

- ✿ Tetrahedral deformation Y_{32} breaks spherical symmetry and symmetry by inversion
- ✿ Degeneracies are 2 and 4
- Large gap

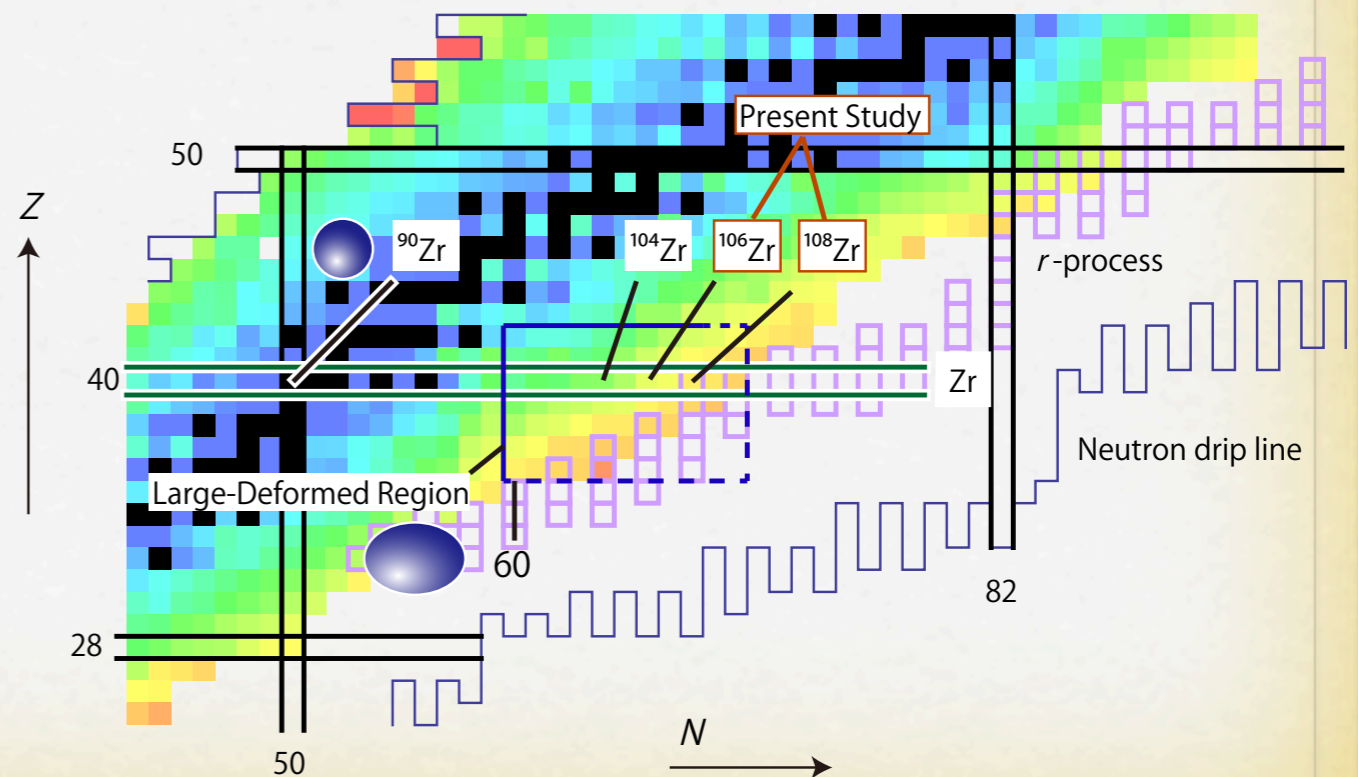


J. Dudek et al., PRL 88, 252502 ('02).
 N. Schunck et al., PRC 69, 061305(R) ('04).



LARGE DEFORMED REGION

- ✿ Sudden onset of large deformation at $N=60$
- ✿ Deformation evolution (β_2)
 $N=70$ is magic number?
- ✿ Evolution of γ degree of freedom in Zr isotopes



Decay Spectroscopy for ^{108}Zr performed at RIBF

T. Sumikama *et al.*, Phys. Rev. Lett. **106**, 202501 (2011)

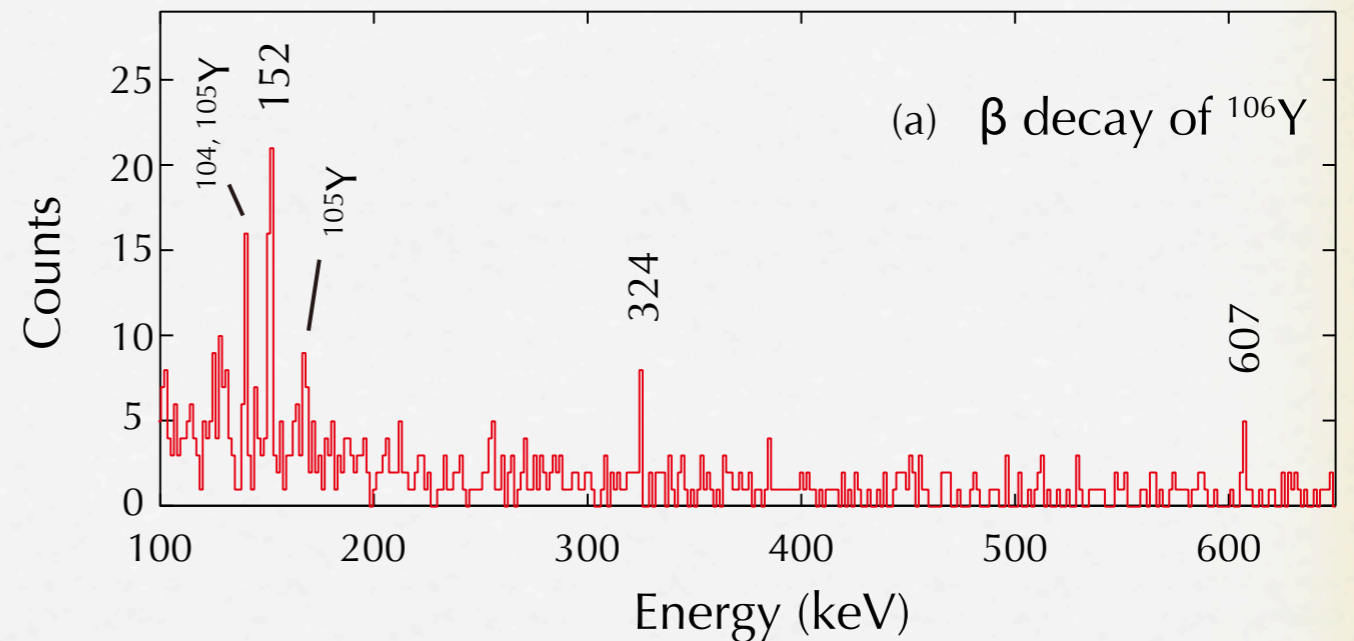
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- * University of York D.G. Jenkins

GAMMA-RAY FROM ^{106}Zr

✿ β -delayed γ -ray from ^{106}Zr (β decay of ^{106}Y)

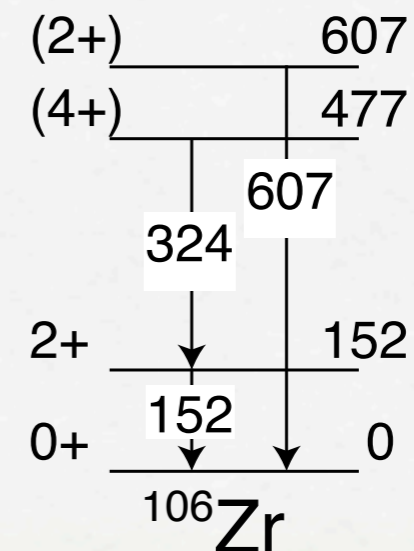
✿ Spin assignment
Most intense peak
152 keV
 $2_1^+ \rightarrow 0_1^+$



✿ Other peaks
324 keV: $4_1^+ \rightarrow 2_1^+$
607 keV: $2_2^+ \rightarrow 0_1^+$

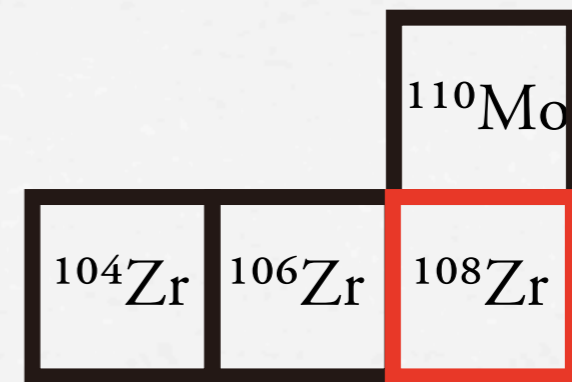
✿ Prediction (IBM)
 $E(4_1^+) = 455$ keV
 $E(2_2^+) = 618$ keV



S. Lalkovski and P. Vanlsacker,
PRC 79, 044307 (2009).



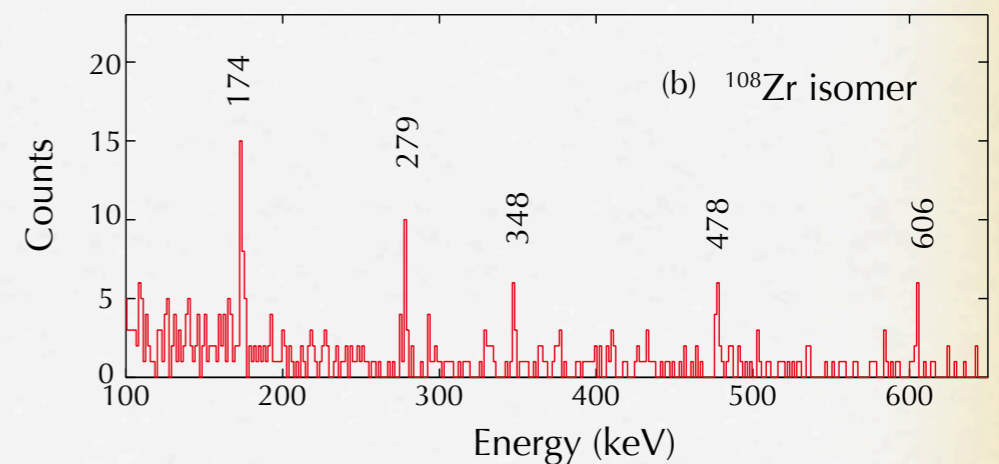
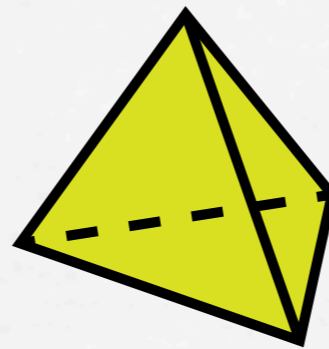
Possible Structure of Isomeric state in ^{108}Zr

- * Long-lived isomer in even-even nucleus (620 ± 150 ns)
- * Energy > 1 MeV
- * Spin > 4



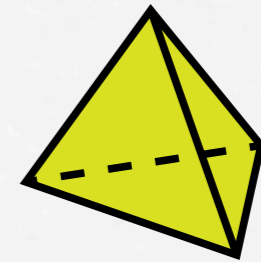
-  Isomer was observed
-  No isomer was observed

1. Tetrahedral shape isomer



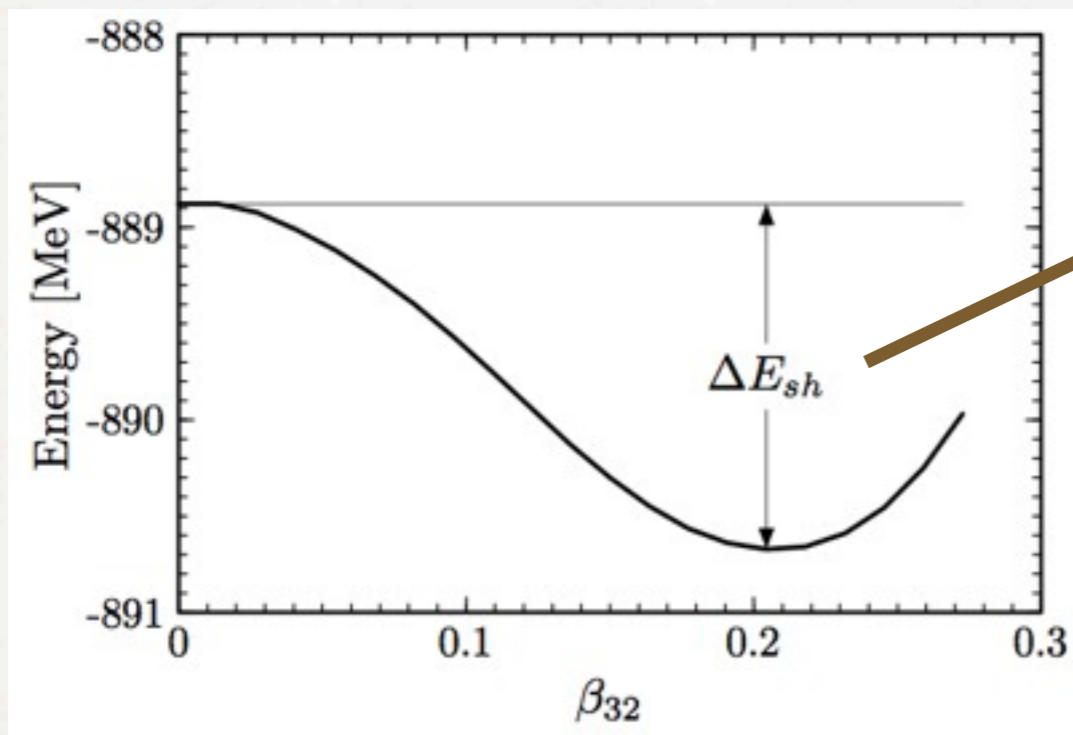
Possible Structure of Isomeric state in ^{108}Zr

- ✿ Long-lived isomer in even-even nucleus (620 ± 150 ns)



1. Tetrahedral shape isomer
Tetrahedral & Spherical shapes

β_{32} deformation



Energy barrier

Total E; HFB with SIII force

Olbratowski et al., Int. Mod. Phys E15, 333 ('06).

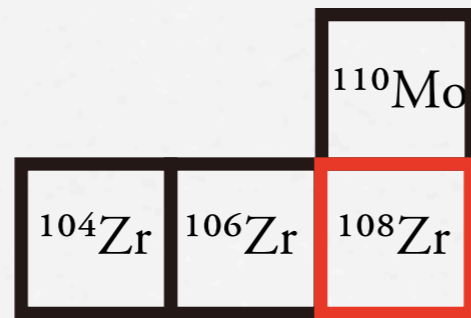
Possible Structure of Isomeric state in ^{108}Zr



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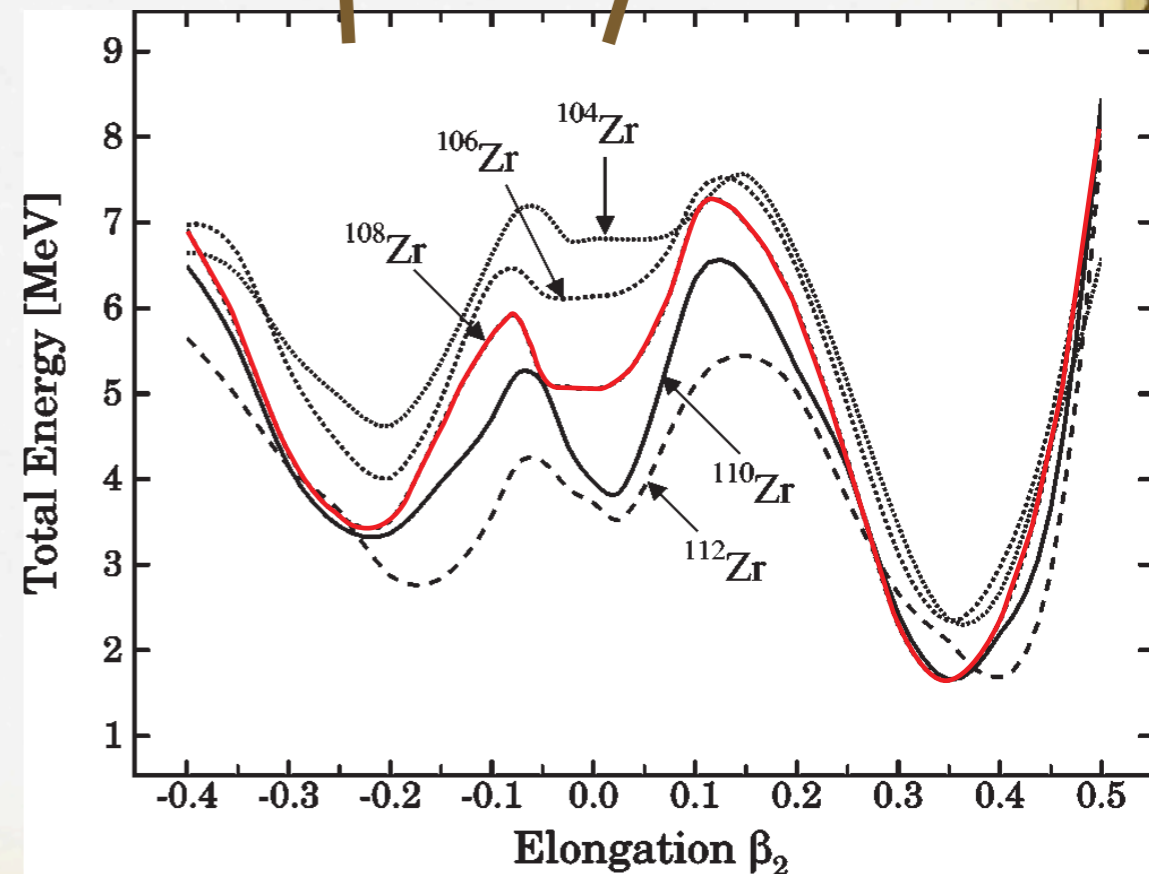
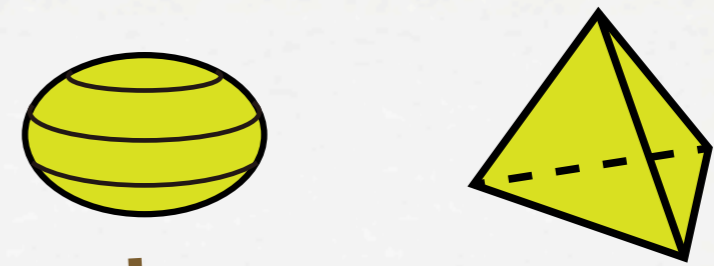
1. Tetrahedral shape isomer

Tetrahedral & quadrupole deformed shapes

N. Schunck et al., PRC 69, 061305(R) ('04).



 Isomer was observed
 No isomer was observed



Possible Structure of Isomeric state in ^{108}Zr

✿ Long-lived isomer in even-even nucleus (620 ± 150 ns)

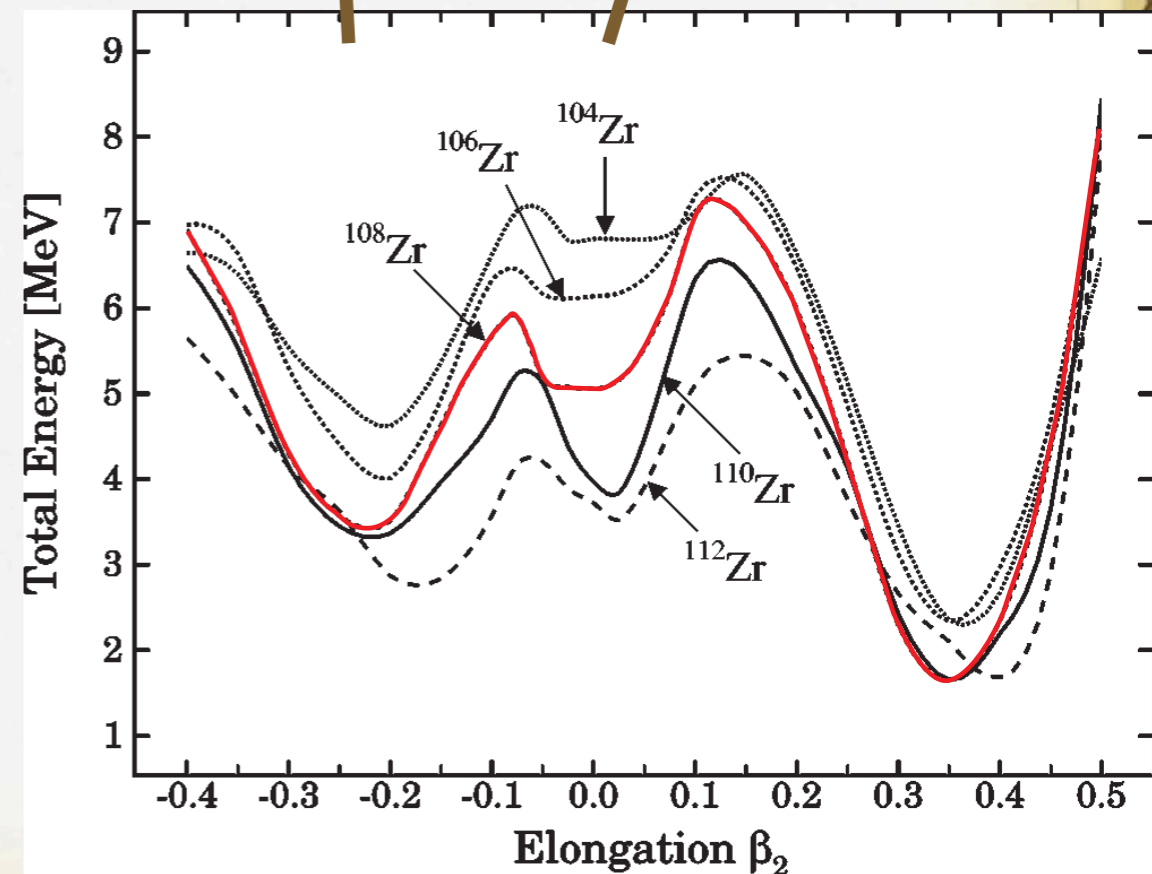
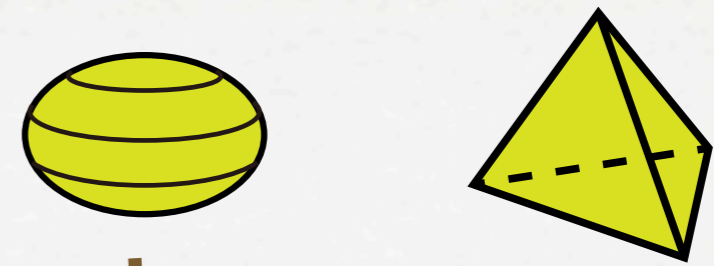
1. Tetrahedral shape isomer
Tetrahedral & quadrupole deformed shapes

N. Schunck et al., PRC 69, 061305(R) ('04).

Candidate for tetrahedral shape isomer

| | | |
|-------------------|-------------------|-------------------|
| | | ^{110}Mo |
| ^{104}Zr | ^{106}Zr | ^{108}Zr |

Isomer was observed
 No isomer was observed



Decay Spectroscopy around ^{108}Zr with EURICA

Decay Spectroscopy of ^{108}Zr

Search for new isomers in ^{110}Zr , $^{110,112}\text{Mo}$

Ground state band of ^{110}Zr

2nd 2^+ state evolution in Zr isotopes

Decay Spectroscopy of ^{108}Zr

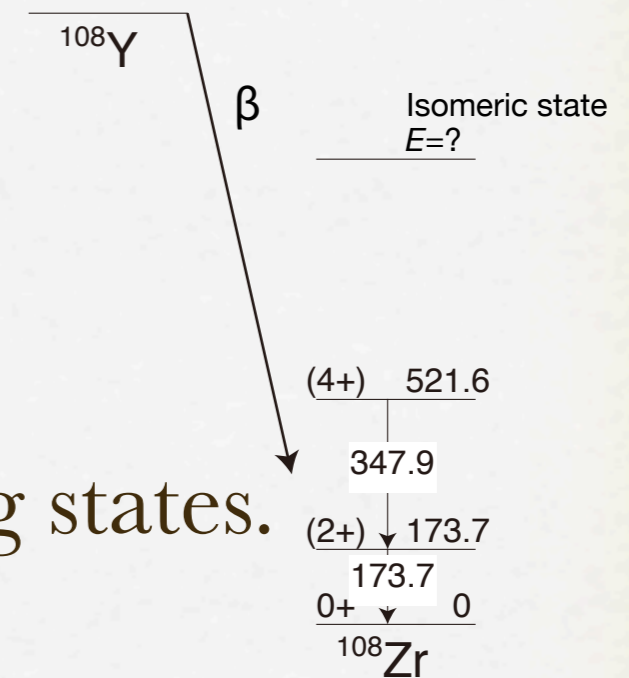
* Spectroscopy of ^{108}Zr isomer with high statistics

Search for missing γ -ray peaks

γ - γ coincidence

* Level scheme

Common peaks correspond to low-lying states.



* Structure from E and $t_{1/2}$

* Tetrahedral shape?

* High- K isomer?

* Other isomer?

Isomer Search In Even-even Nuclei

✱ $N=68$: ^{110}Mo with high statistics

✱ $N=70$: ^{110}Zr and ^{112}Mo

✱ 1. **Tetrahedral shape isomer** in ^{108}Zr

a. Tetrahedral shape isomer in ^{110}Zr

b. Ground state of ^{110}Zr is predicted to be tetrahedral shape.

N. Schunk et al., PRC **69**, 061305(R) (2004).

Prolate shape may become an isomer??

✱ 2. Isomer of ^{108}Zr is the **high K isomer**

Two quasineutron states around ^{108}Zr

F. R. Xu et al., PRC **65**, 021303(R) (2002).

Ground-State Structure of ^{110}Zr

- ✿ Reduction of spin-orbit interaction?
- ✿ Test of predicted transition to spherical shape at $N=70$
- ✿ Low-lying states
 - ✿ Isomer in ^{110}Zr
 - ✿ No chance for beta decay with 5 pnA

EVOLUTION OF 2ND 2+ STATE IN ZR ISOTOPES

✿ ^{106}Zr case

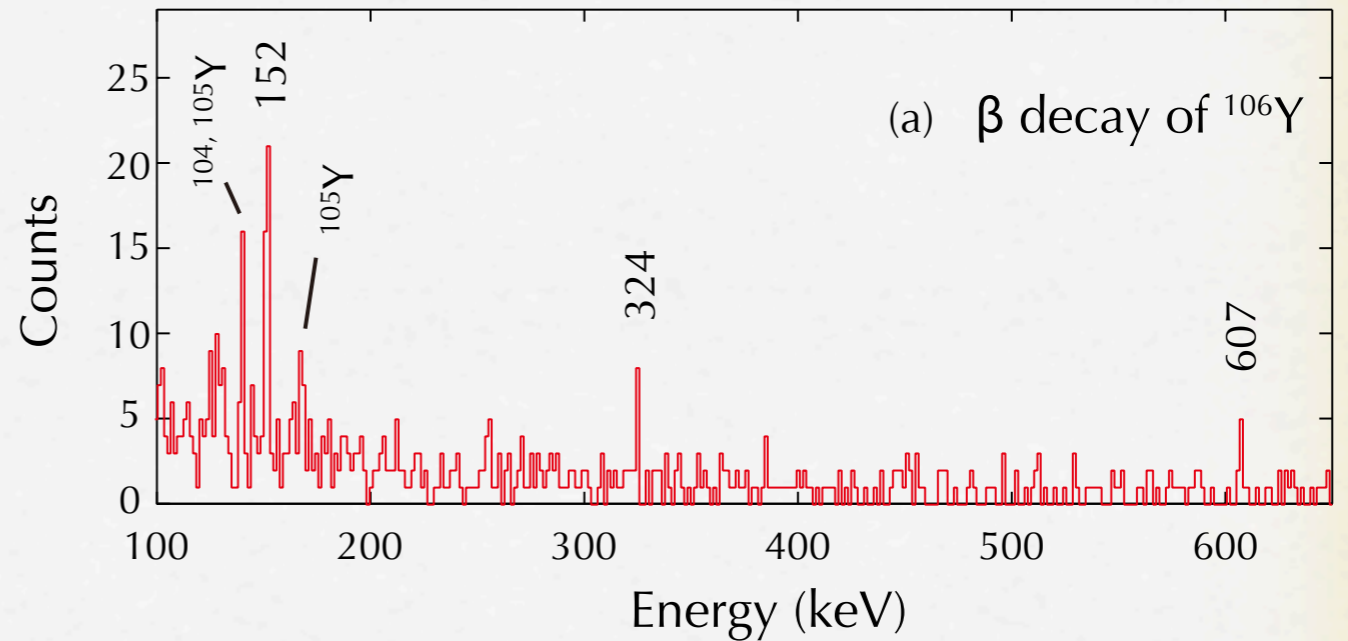
✿ 607 keV: $2_2^+ \rightarrow 0_1^+$

✿ Prediction (IBM)

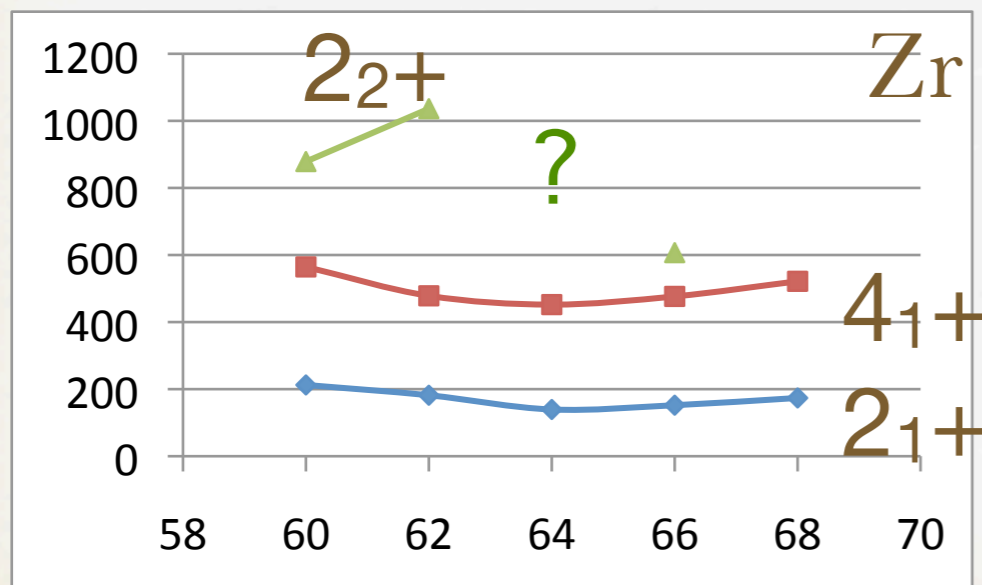
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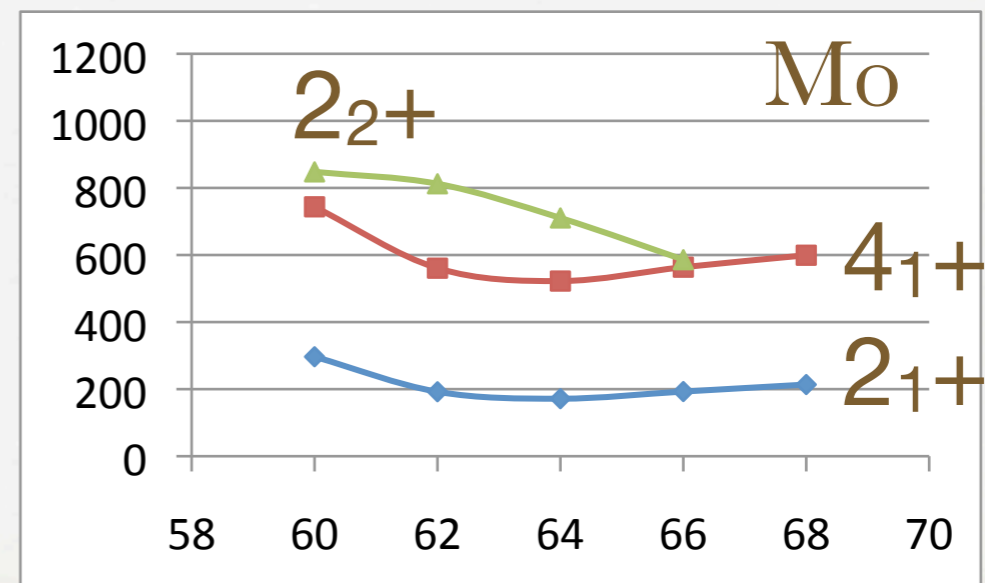


E (keV)




N

E (keV)



N



Thank you for your attention

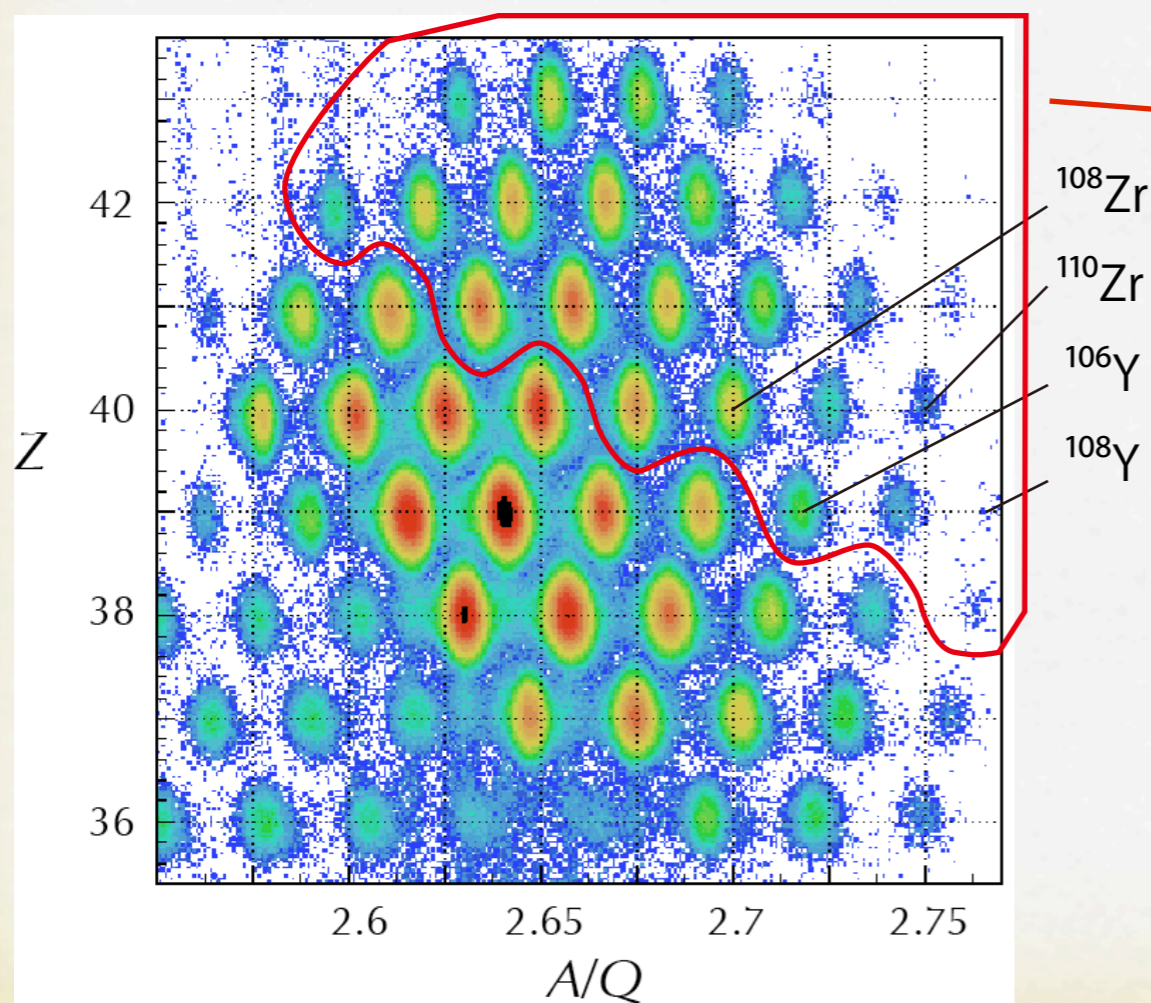


Beam Time Estimation

USE OF HIGH INTENSITY BEAM

- ✿ High intensity beam
from ~ 0.3 pA to 5 pA (avg. 3 pA)
- ✿ Keep Total Yield to ~ 100 cps

✿ Separation @ BigRIPS



$$N \geq 67$$

✿ Ratio: $(N \geq 67) / (\text{All}) = 0.13$

DECAY SPECTROSCOPY WITH EURICA

✱ Improvement of γ -ray counts from previous exp.

✱ γ -ray efficiency: 4 clovers to EURICA

x 7

✱ High intensity beam

from ~ 0.3 pnA to 5 pnA (avg. 3 pnA)

x 10

✱ Beam time (8 days)

x 4

✱ Total

x 280

Previous Exp.
Isomer: up to ^{108}Zr
 β - γ : up to ^{106}Zr



New Exp.
Isomer: up to ^{110}Zr
 β - γ : up to ^{108}Zr

BEAM TIME ESTIMATION

✱ β - γ & Isomer spectroscopy around ^{110}Zr (N=67 - 72)

✱ 8 days

✱ Beam tuning/Circuit & Detector check

✱ 2 days

✱ Total

✱ 10 days