Decay Spectroscopy of ^{160}Eu Using the GRIFFIN Spectrometer

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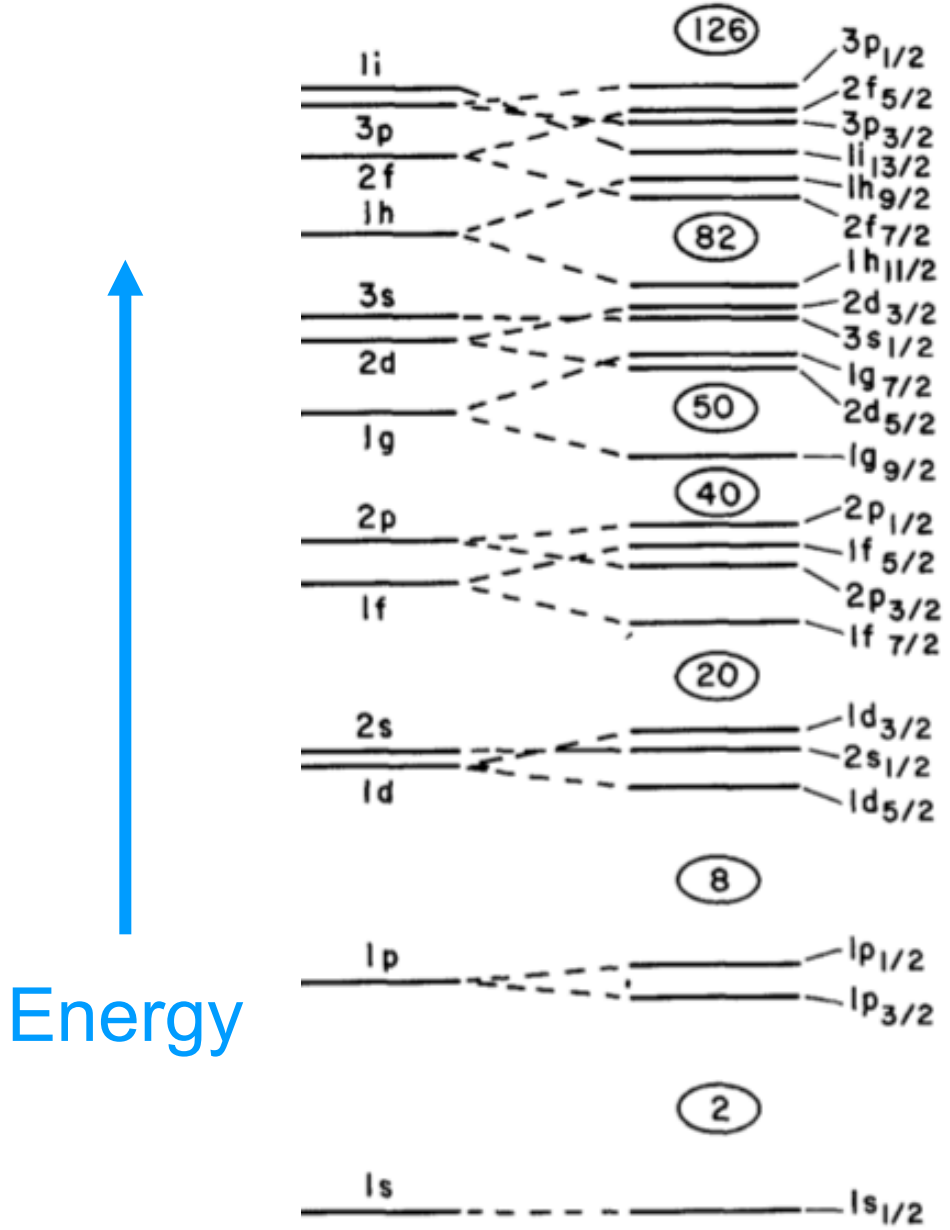
2019-02-16

Nuclear Shell Model

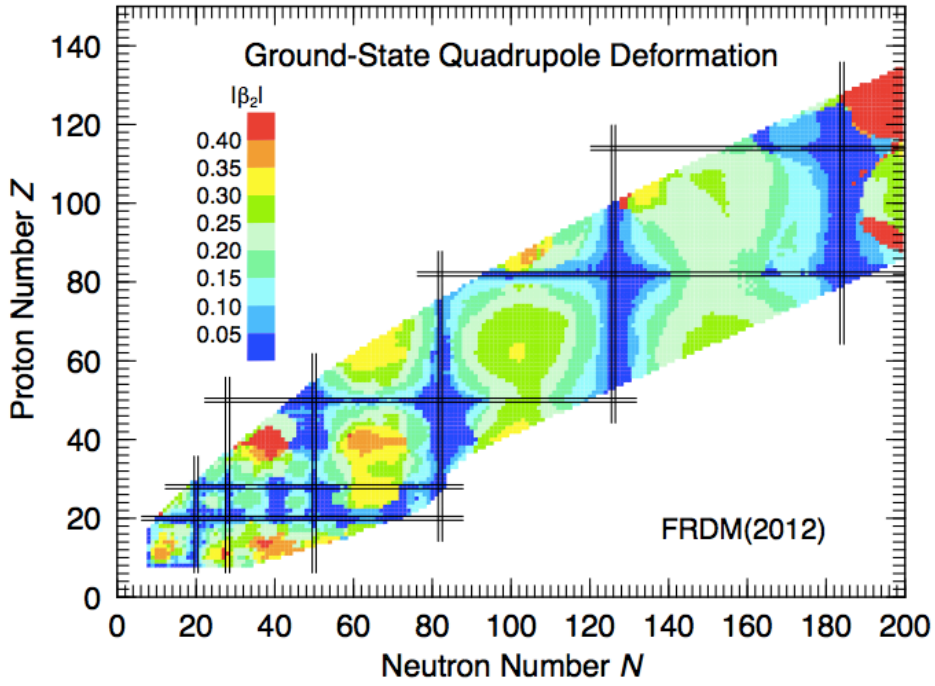
- Describes energies and wave functions of nucleons
  - Closed shells at certain nucleon number

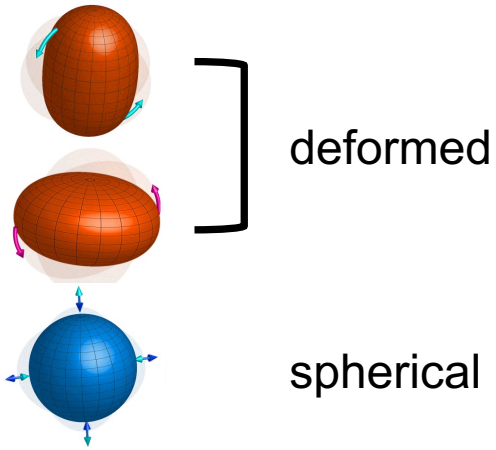


R.F Casten. *Nuclear Structure from a Simple Perspective* (1990).

Nuclear Structure

- Deformed nuclei away from shell closures
- Investigate nuclei in regions of deformation
  - Improve theoretical models





deformed

spherical

P. Möller *et al., Atomic Nuclear Data Tables,* 109-110 (2016).

Nuclear Structure

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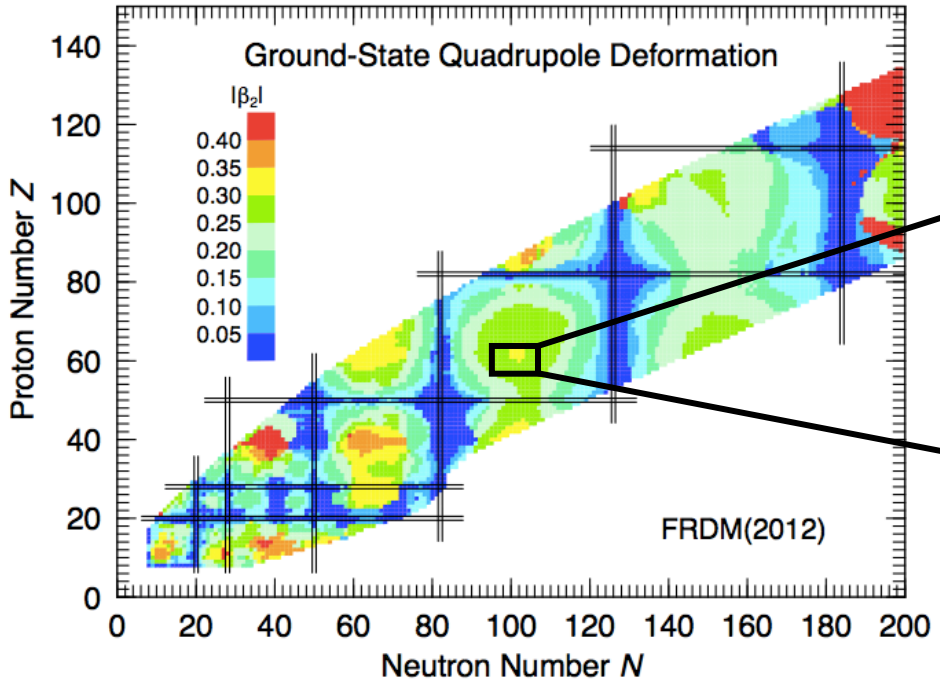
  - Improve theoretical models



^{160}Eu β-decay to ^{160}Gd

Dy161 5/2+ 18.9	Dy162 0+ 25.5	Dy163 5/2- 24.9	Dy164 0+ 28.2	Dy165 2.334 h 7/2+ *	Dy166 81.6 h 0+	Dy167 6.20 m (1/2-)	Dy168 8.7 m 0+	Dy169 39 s (5/2-)	Dy170 0+	Dy171	Dy172 0+
Tb160 72.3 d 3-	Tb161 6.88 d 3/2+	Tb162 7.60 m 1-	Tb163 19.5 m 3/2+	Tb164 3.0 m (5+)	Tb165 2.11 m (3/2+)	Tb166	Tb167	Tb168	Tb169	Tb170	Tb171
Gd159 18.479 h 3/2-	Gd160 0+ 21.86	Gd161 3.66 m 5/2-	Gd162 8.4 m 0+	Gd163 68 s (5/2-)	Gd164 45 s 0+	Gd165	Gd166 0+	Gd167	Gd168 0+	Gd169	
Eu158 45.9 m (1-)	Eu159 18.1 m 5/2+	Eu160 38 s 1(-)	Eu161 26 s	Eu162 10.6 s	Eu163	Eu164	Eu165	Eu166	Eu167		

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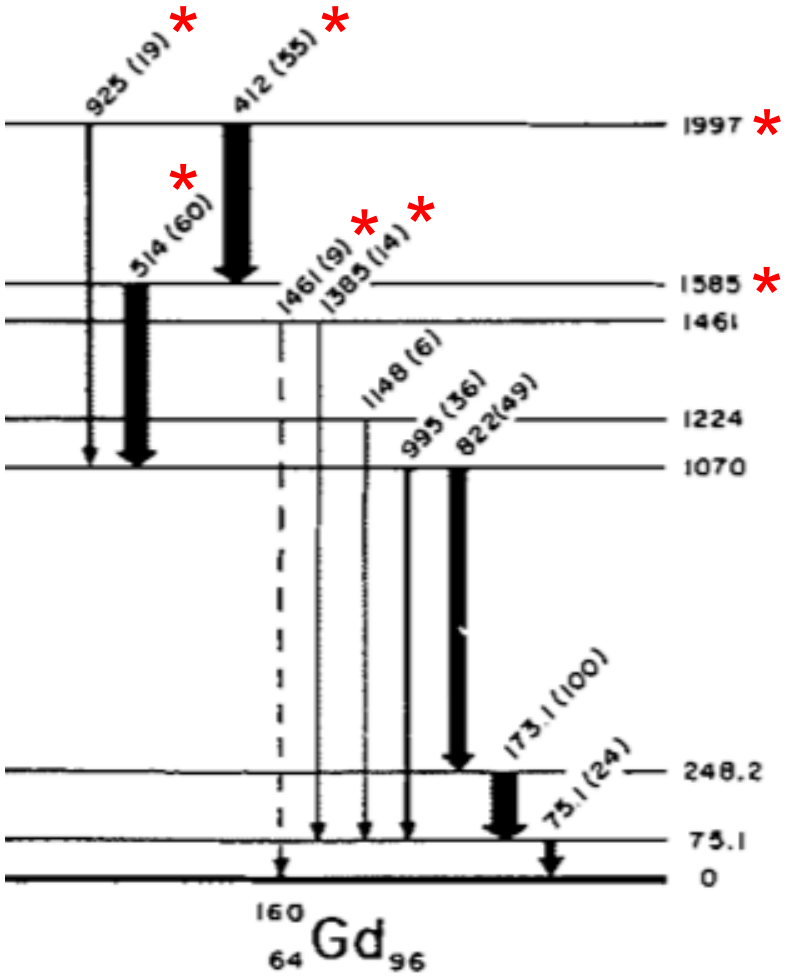
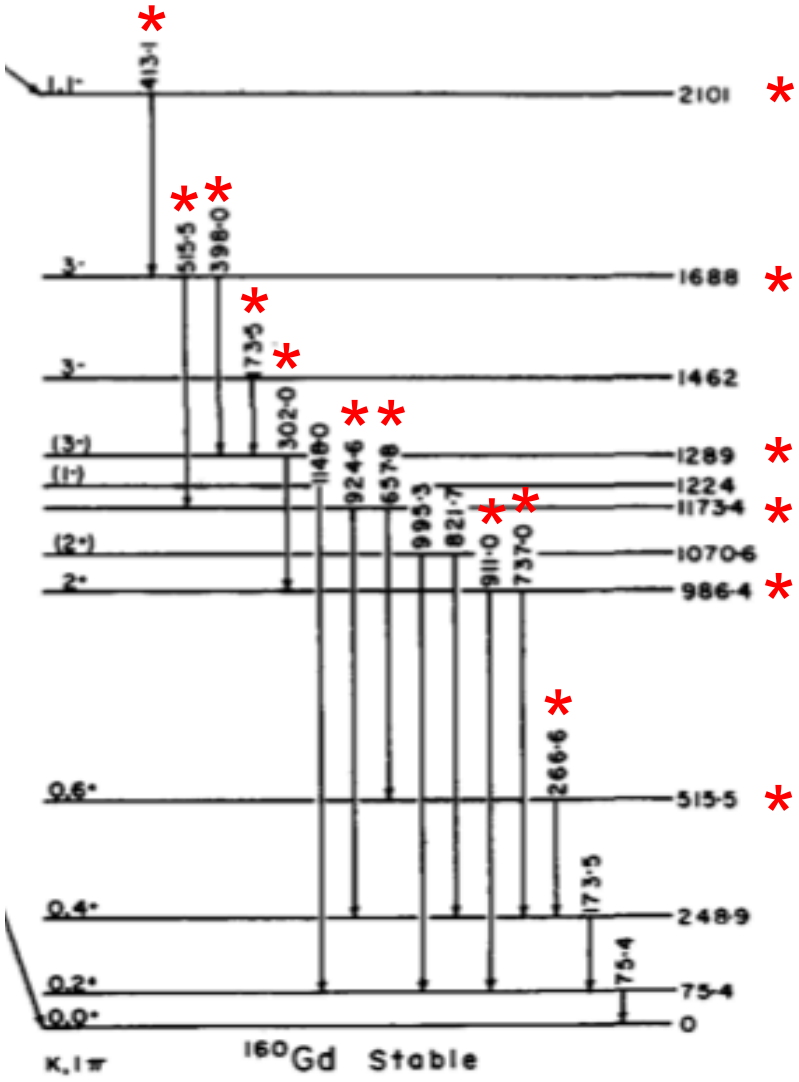
P. Möller *et al., Atomic Nuclear Data Tables,* 109-110 (2016).

Previous Work on $^{160}Eu \rightarrow {}^{160}Gd$

- Disagreeing results from 1973



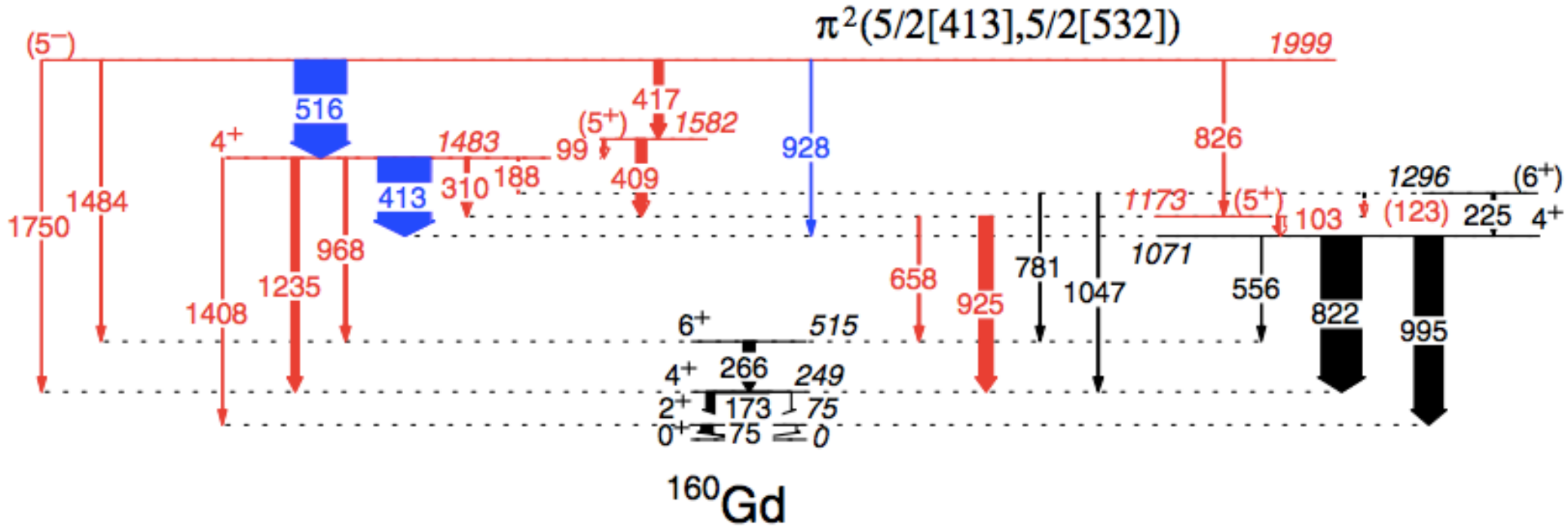
J.M. D'Auria *et al., Can. J. Phys.* **51**, 686 (1973).



N.A. Morcos *et al., J. Inorg. Nucl. Chem.* **35**, 3659 (1973).

Recent Work on ^{160}Eu → ^{160}Gd

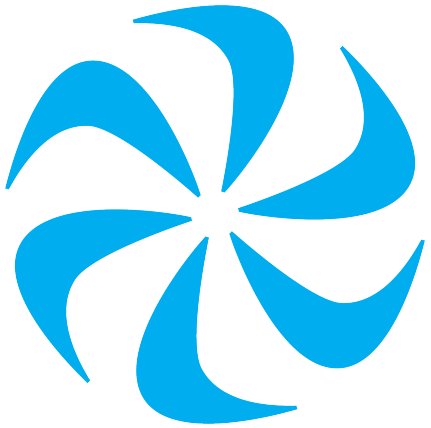
- Improved partial level scheme (2018)
  - ~2.4 MeV between Q_{β^-} and highest level



D.J. Hartley *et al., Phys. Rev. Lett.,* 120:182502 (2018).

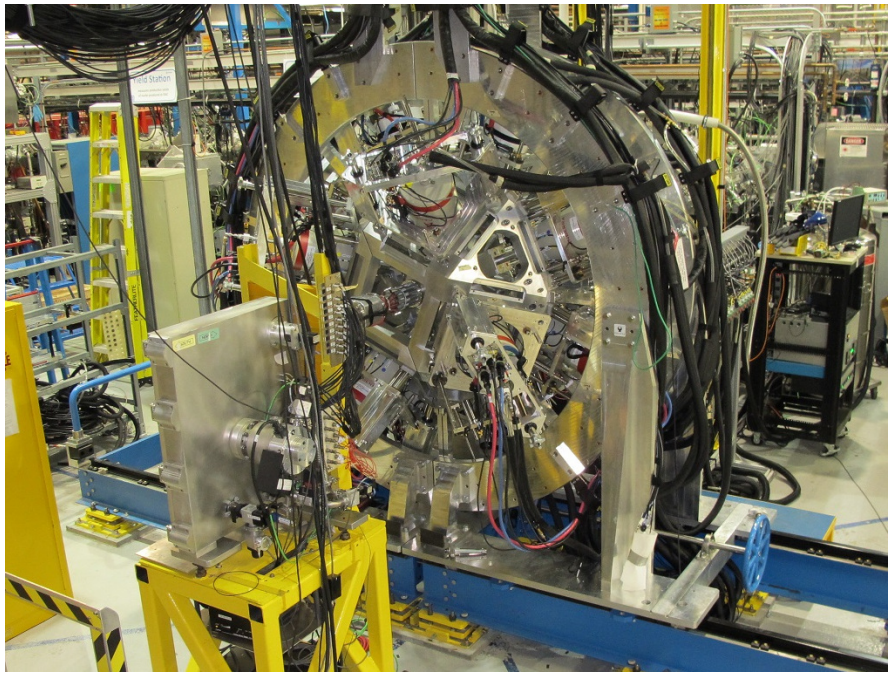
Experimental Setup

- Zero Degree Scintillator for beta detection
- 15 large-volume GRIFFIN High Purity Germanium detectors



Cyclotron and production targets

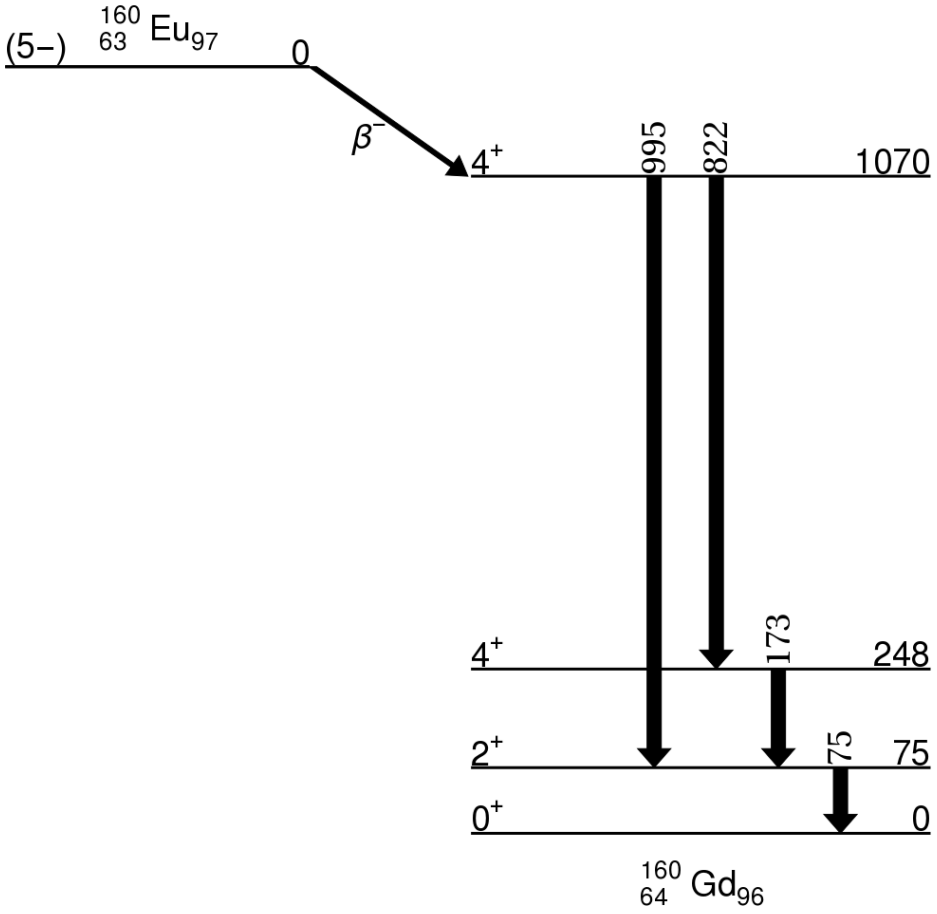
Moving Tape Collector and Zero Degree Scintillator

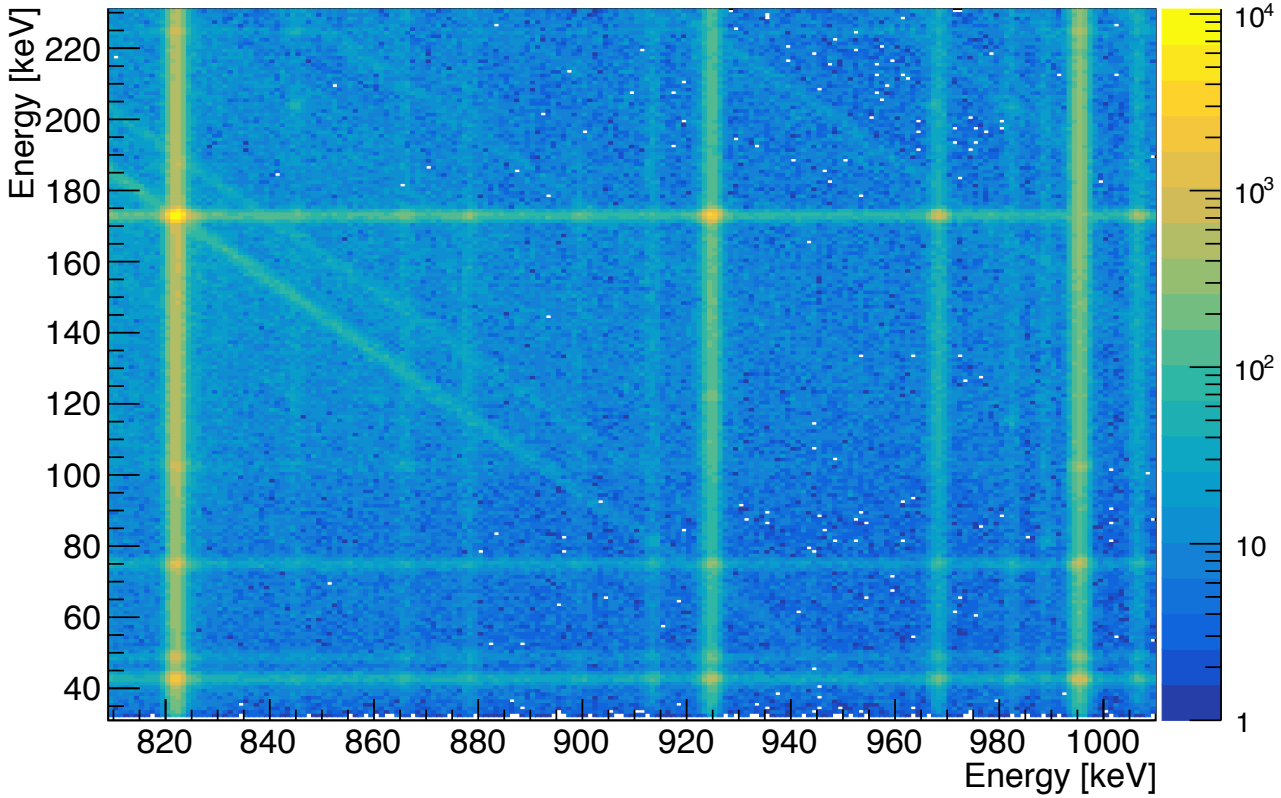


Gamma-**R**ay **I**nfrastructure **F**or **F**undamental **I**nvestigations of **N**uclei

Coincidence Analysis

- Events within given time are in coincidence → same decay
- Coincident transitions in cascade
- Parallel transitions are not in coincidence





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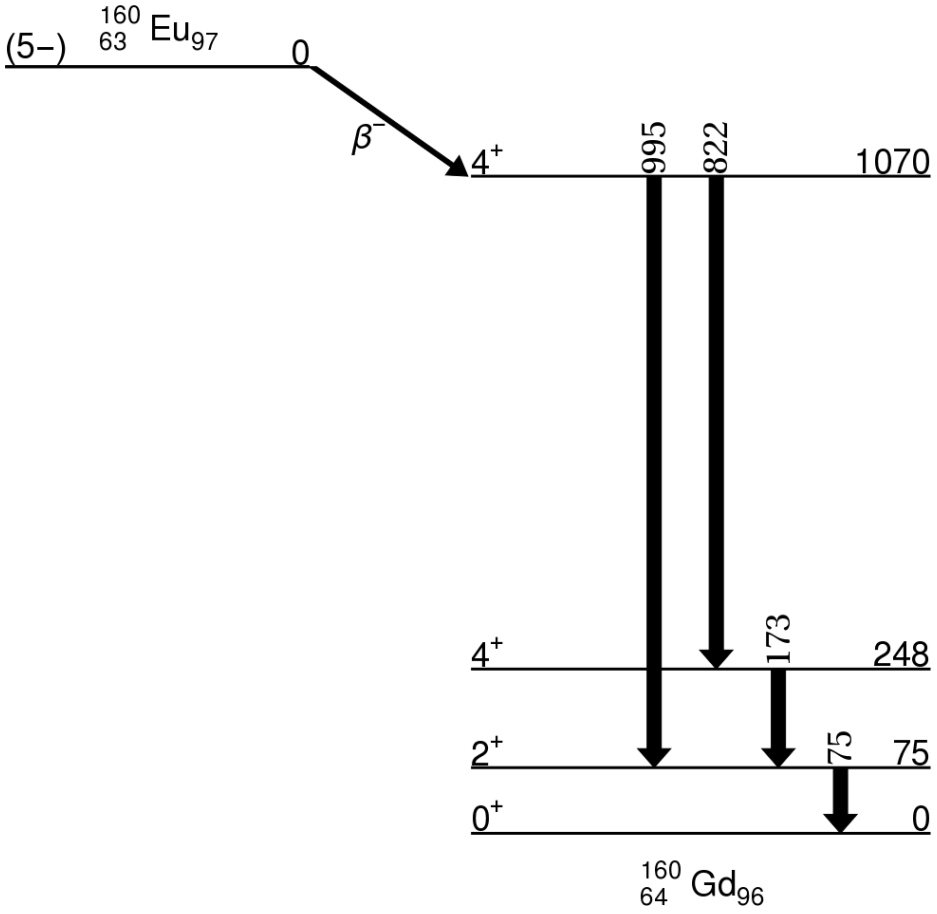

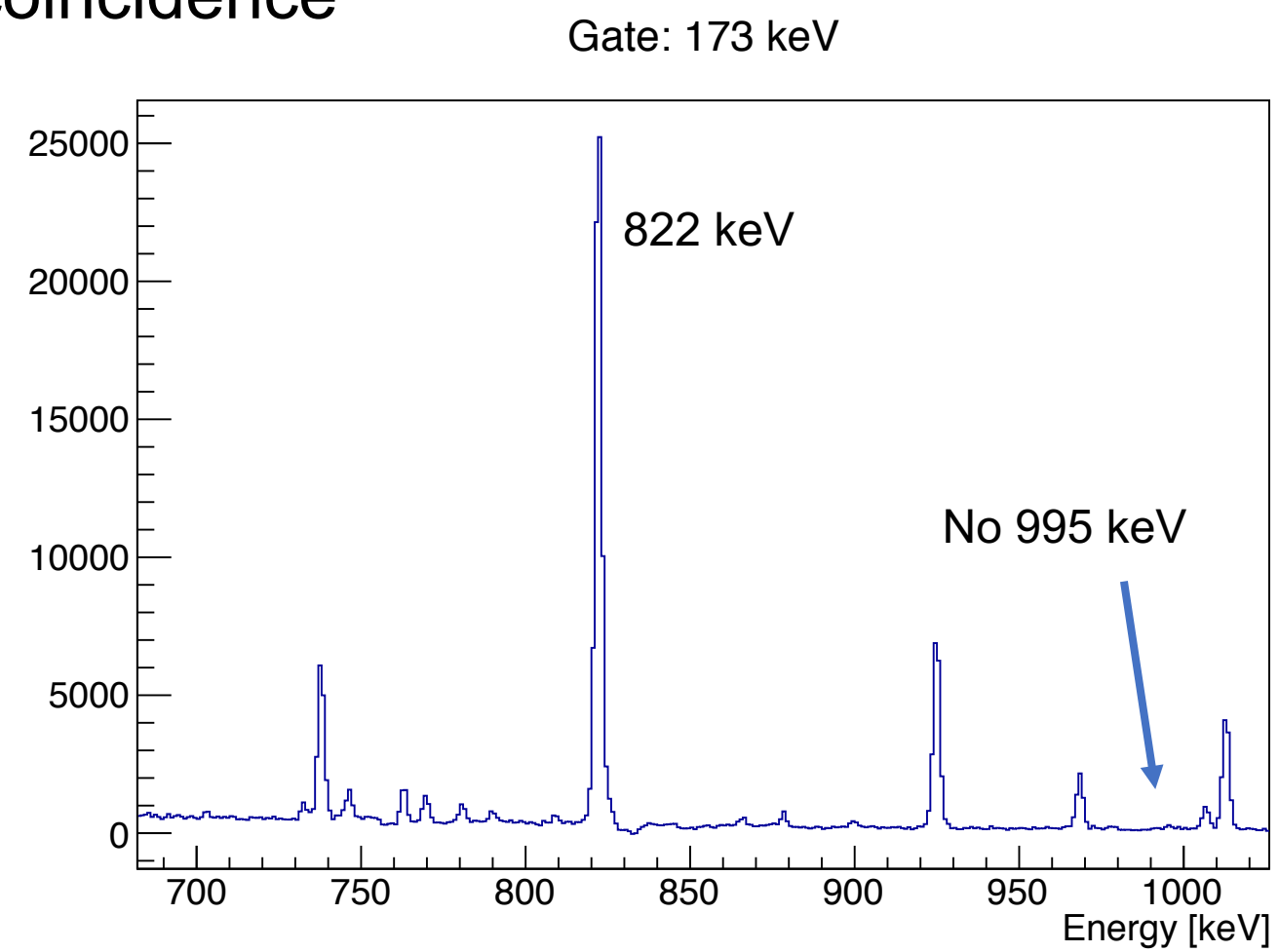

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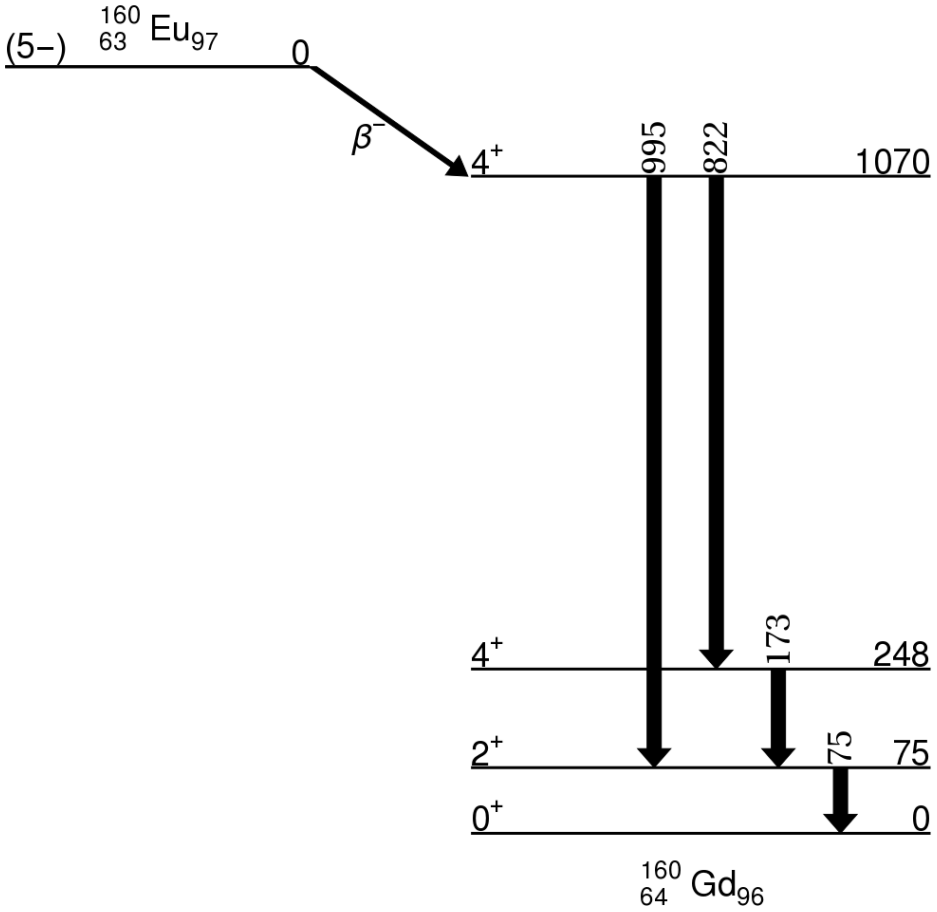
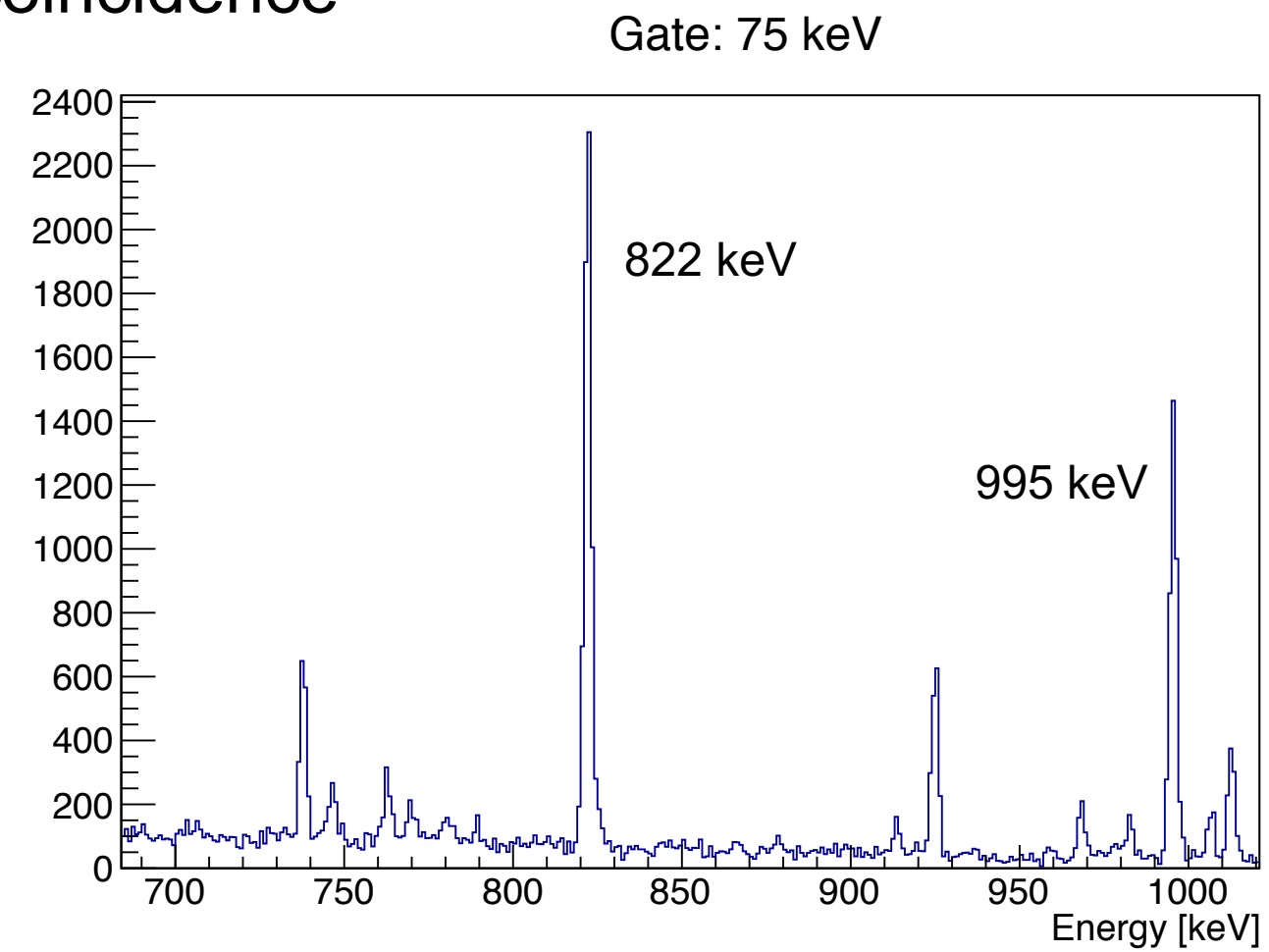
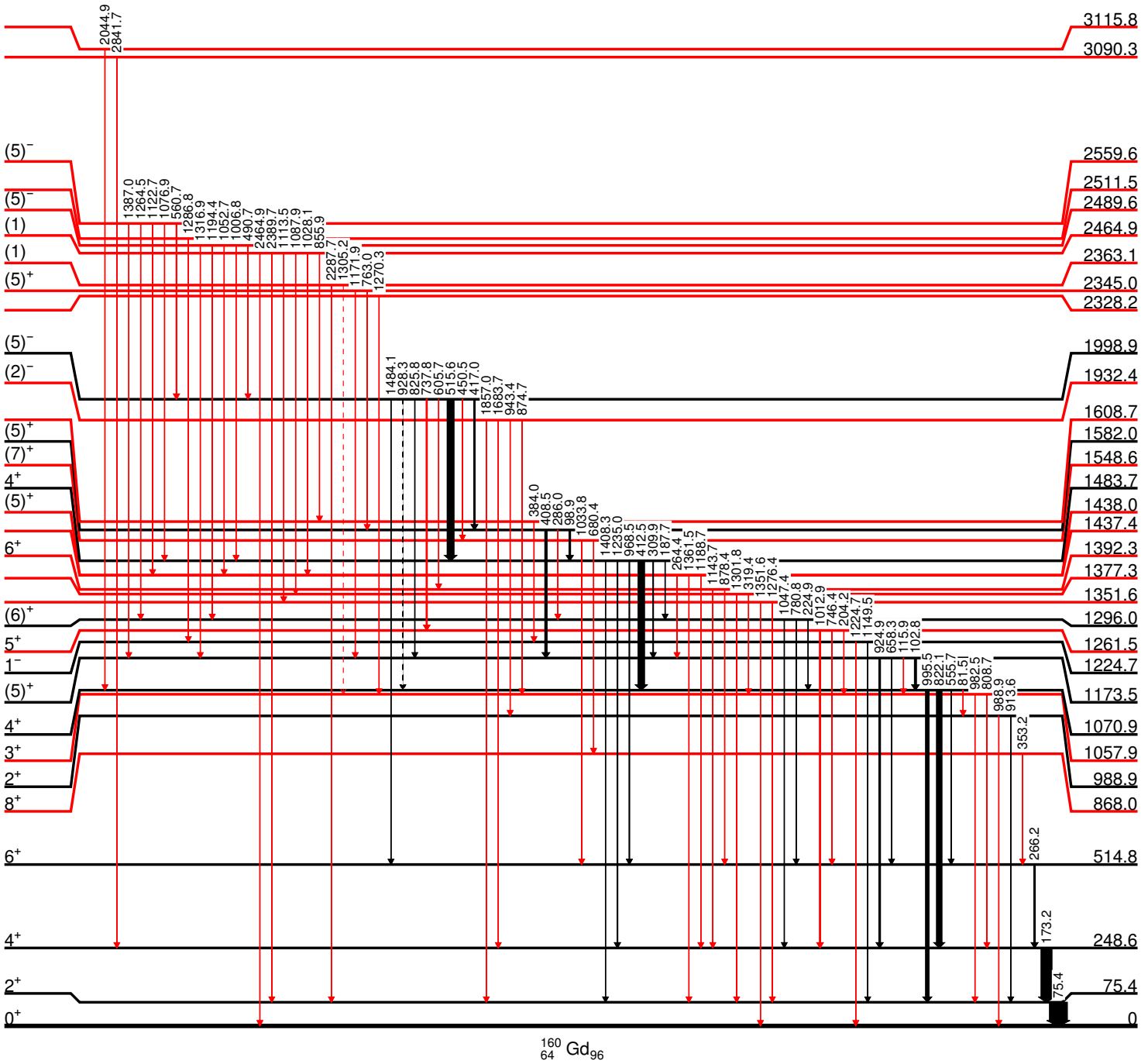




Structure of ^{160}Gd

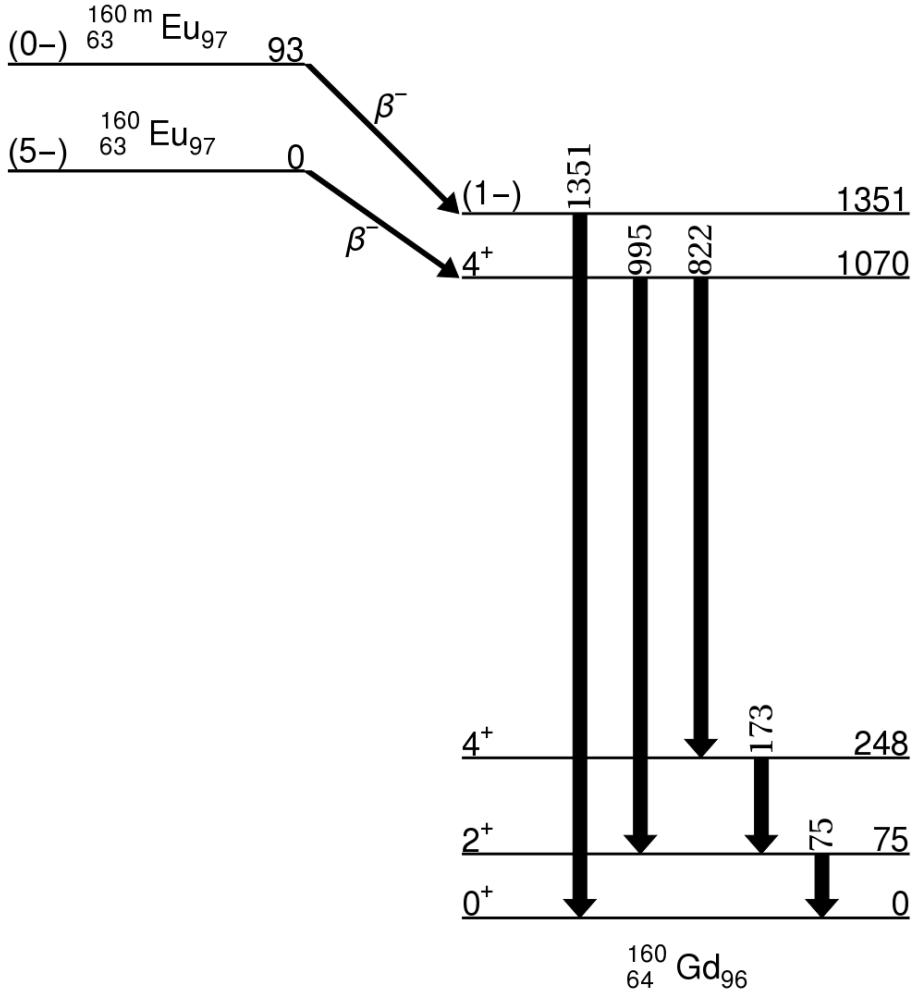
- Confirmation of:
  - 5/7 excited states [1]
  - 7/11 excited states [2]
  - 9/9 excited states [3]
- Previously unpublished:
  - 21 excited states
  - 56 transitions

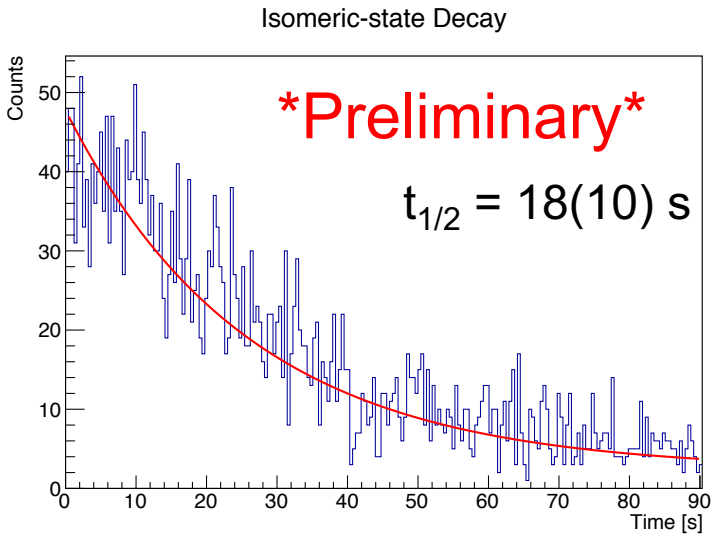
Preliminary

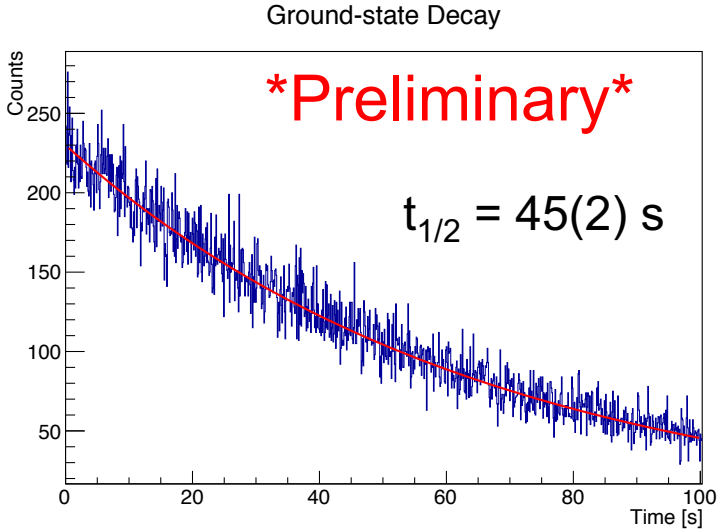


[1] J.M. D'Auria *et al., Can. J. Phys.* **51**, 686 (1973).
[2] N.A. Morcos *et al., J. Inorg. Nucl. Chem.* **35**, 3659 (1973).
[3] D.J. Hartley *et al., Phys. Rev. Lett.,* 120:182502 (2018).

Multiple Decaying States







State	This work	D.J. Hartley *et al.*
0^- isomeric state	$t_{1/2}$ = 18(10) s	$t_{1/2}$ = 30.8(5) s
5^- ground state	$t_{1/2}$ = 45(2) s	$t_{1/2}$ = 42.6(5) s

D.J. Hartley *et al., Phys. Rev. Lett.,* 120:182502 (2018).

Summary

- New information on ^{160}Eu$\rightarrow$^{160}Gd β-decay
- Confirmation of most known levels and transitions
- 21 new excited states and 56 new transitions

Thank you
Merci

D. Yates[1,2], R. Krücken[1,2], I. Dillmann[1,3], F.A. Ali[4], C. Andreiou[5], W. Ashfield[6], Z. Beadle[6], N. Bernier[1,2], S. Bhattacharjee[1], H. Bidaman[4], V. Bildstein[4], D. Bishop[1], M. Bowry[1], C. Burbage[4], R. Caballero-Folche[1], D.Z. Chaney[7], D. Cross[5], A. Diaz Varela[4], M. Dunlop[4], R. Dunlop[4], L. Evitts[1,2], F.H. Garcia[5], A.B. Garnsworthy[1], P.E. Garrett[4], S. Georges[1], F. Ghazi Moradi[4], S. Gillespie[1], J. Henderson[1], S. Jigmeddorj[4], C. Jones[1,8], K. Leach[9], B.K. Luna[7], A. MacLean[4], C. Natzke[9], B. Olaizola[1], H. Patel[1,10], C. Petrache[11], A. Radich[4], M.M. Rajabali[7], P. Regan[8], Y. Saito[1,2], J. Smallcombe[1], J.K. Smith[6], M. Spencer[1,8], M. Spieker[12], C.E. Svensson[4], K. Whitmore[5], T. Zidar[4]

1 TRIUMF
2 UBC
3 UVic
4 Guelph
5 SFU
6 Reed College
7 Tennessee Tech
8 Surrey
9 Colorado Mines
10 Waterloo
11 Orsay
12 NSCL

Discovery, accelerated