Spectroscopy of ^{139}Ce

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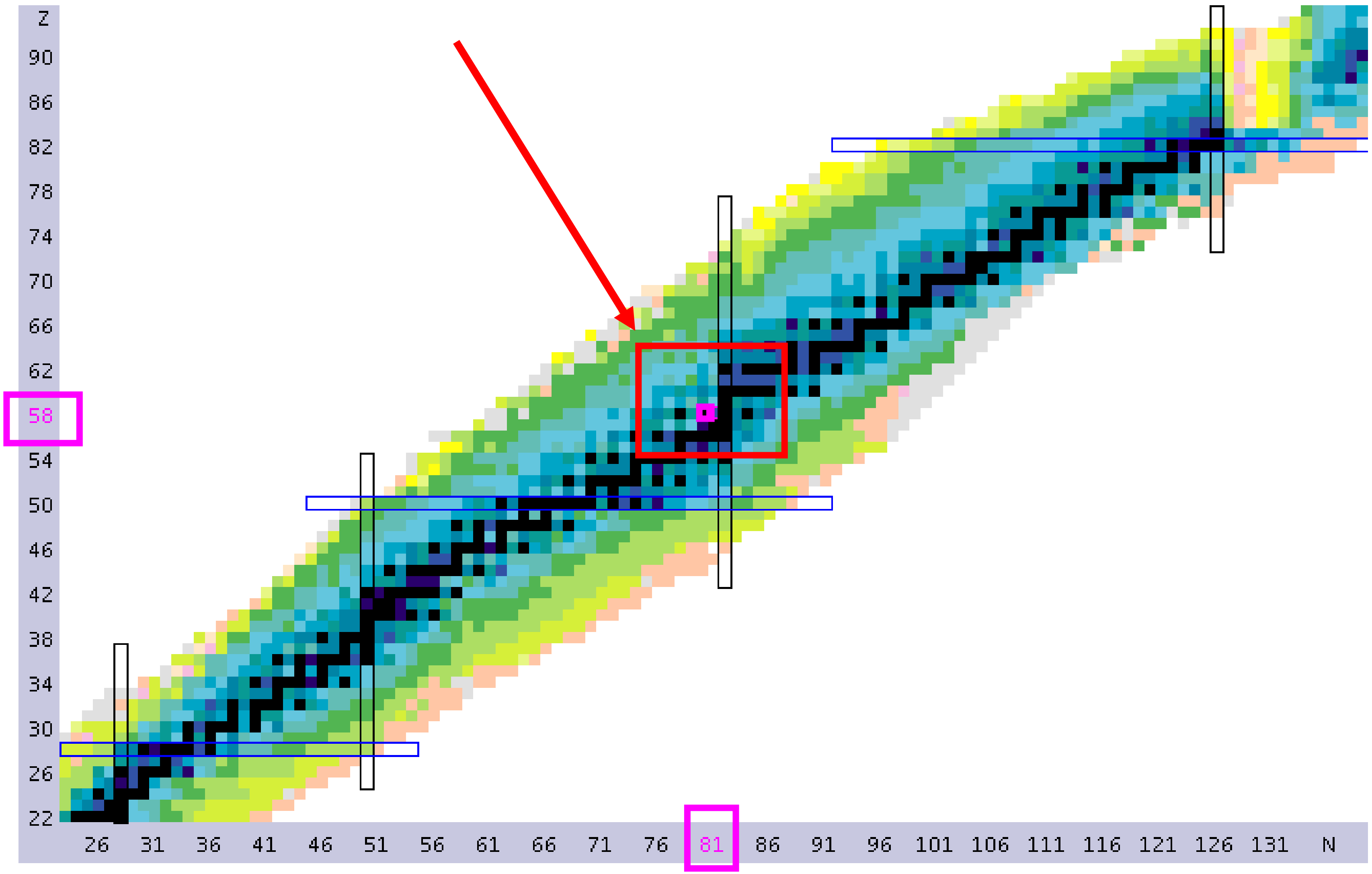
1. Introduction

Around Shell closure N = 82. Why?



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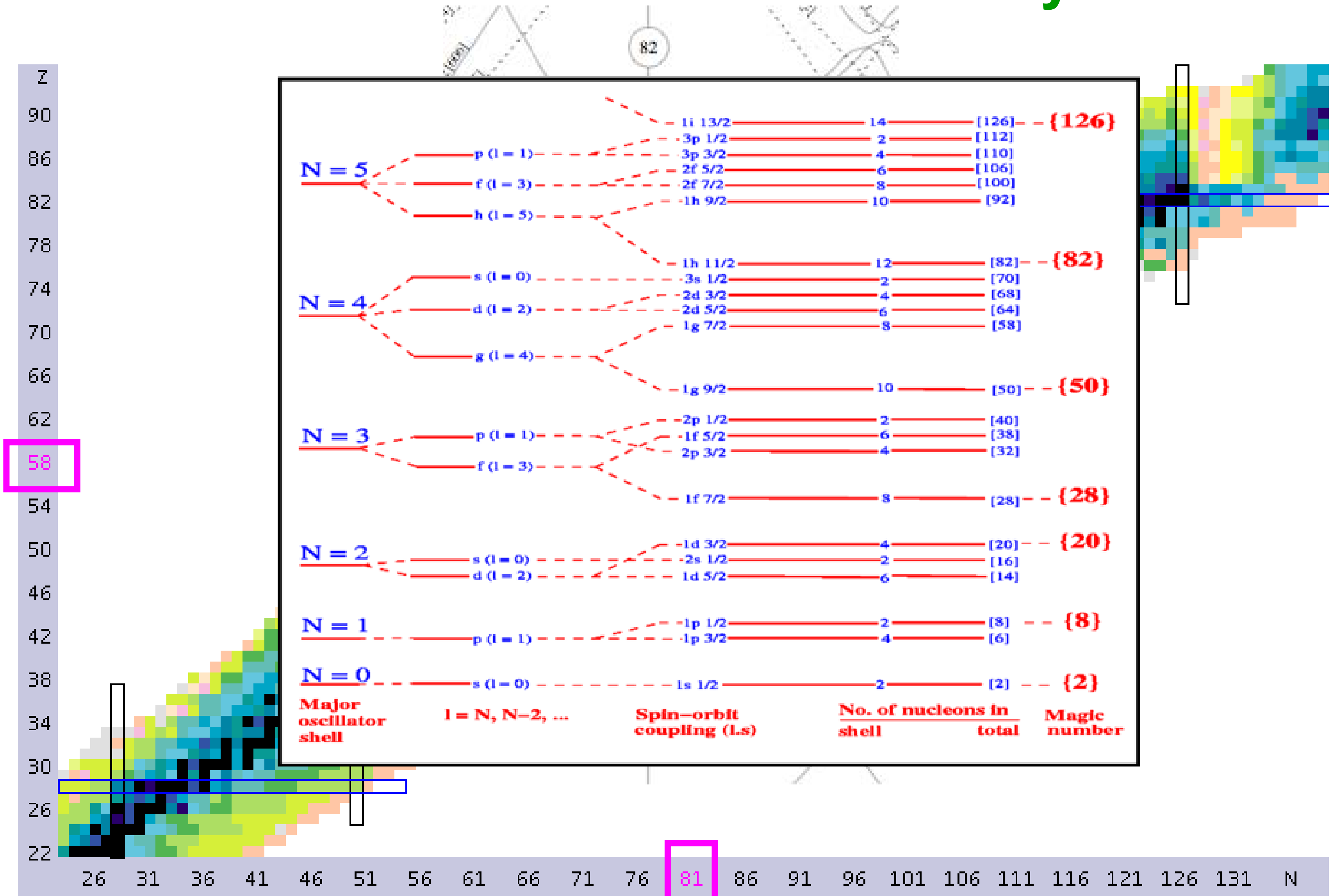

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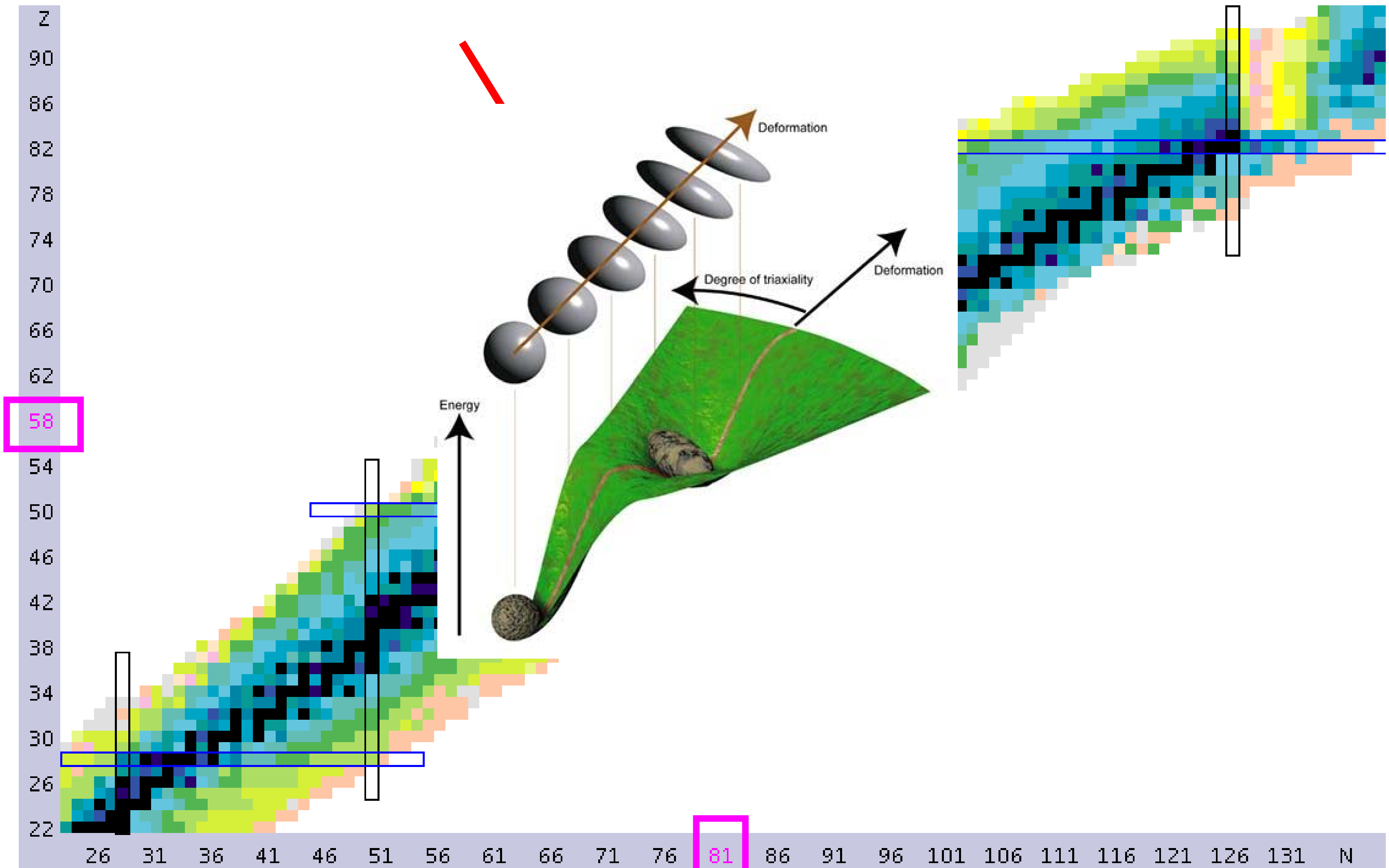

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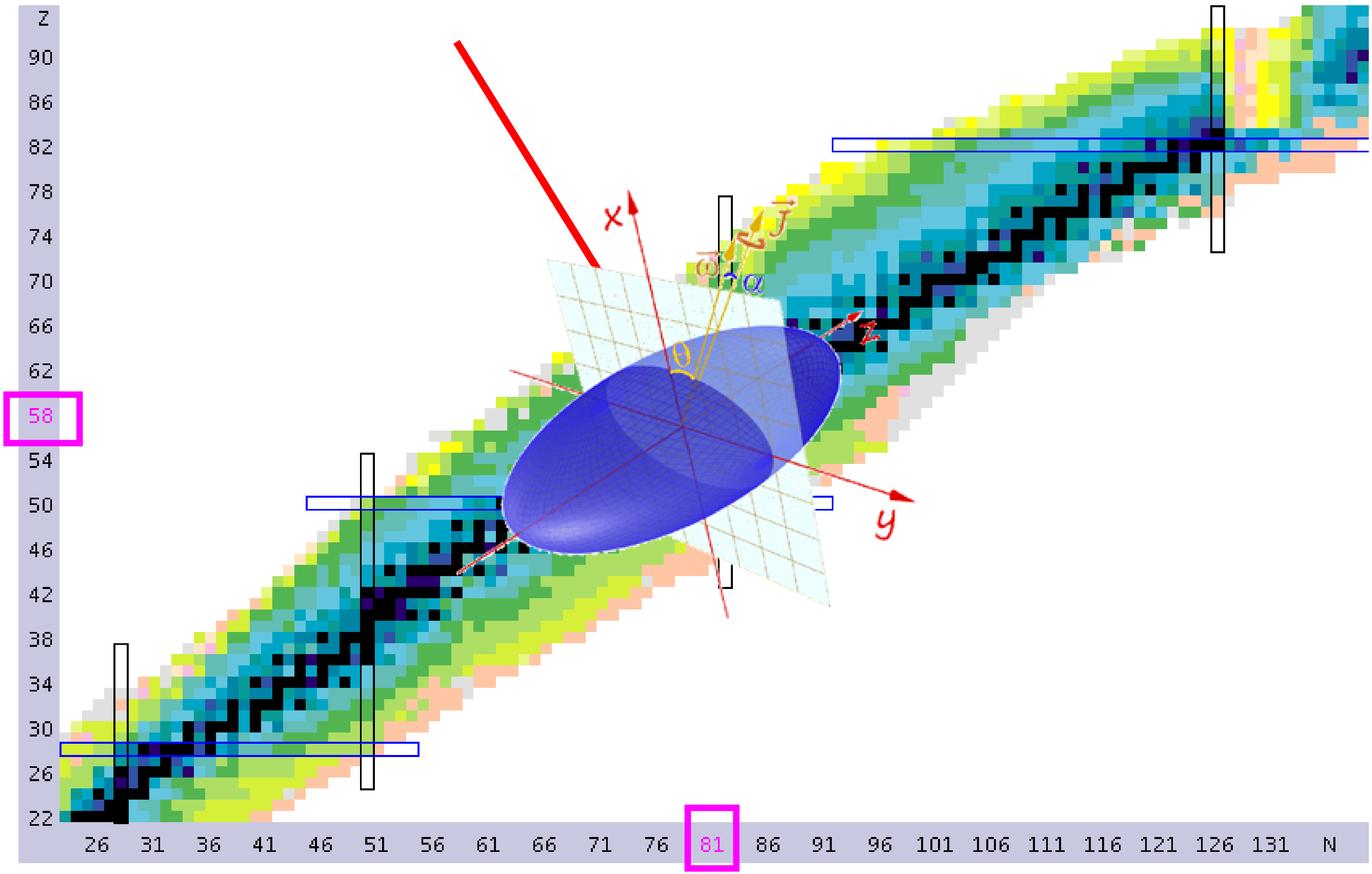
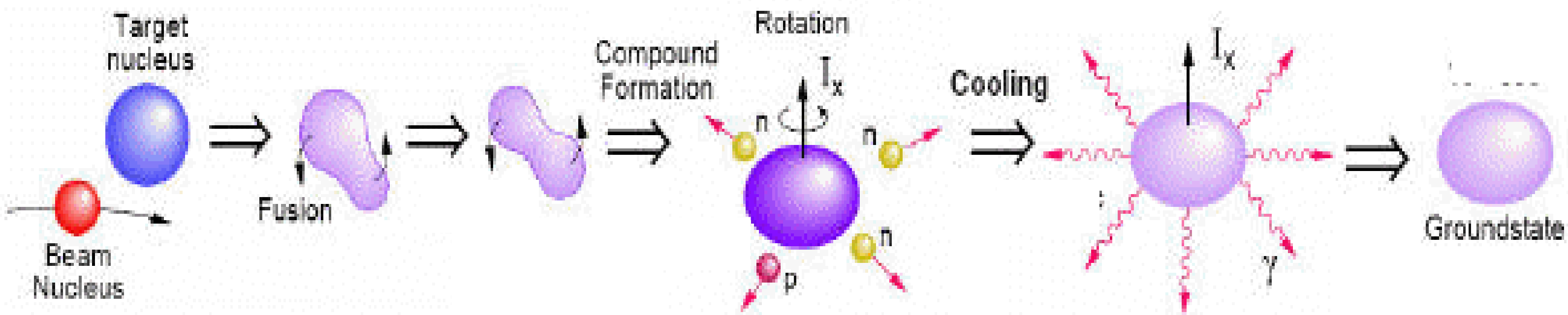


2. Experiment description

Fusion-evaporation Reaction



$^{14}C^* + {}^{130}Te \longrightarrow {}^{144}Ce^*$ →

- $6n + {}^{138}Ce^*$
- **$5n + {}^{139}Ce^*$**
- ..
- ..

- E_{beam} = 82 MeV
- Target ^{130}Te thickness = 2 mg/cm^2, evaporated on a 120 mg/cm^2 Bi backing and 136 mg/cm^2 Cu for heat dissipation

PACE4:

σ_{tot} ~ 1.5 b

σ_{138Ce^*} = 1040 mb ~ 70 %

σ_{139Ce^*} = 190 mb ~ 13 %

2. Experiment description

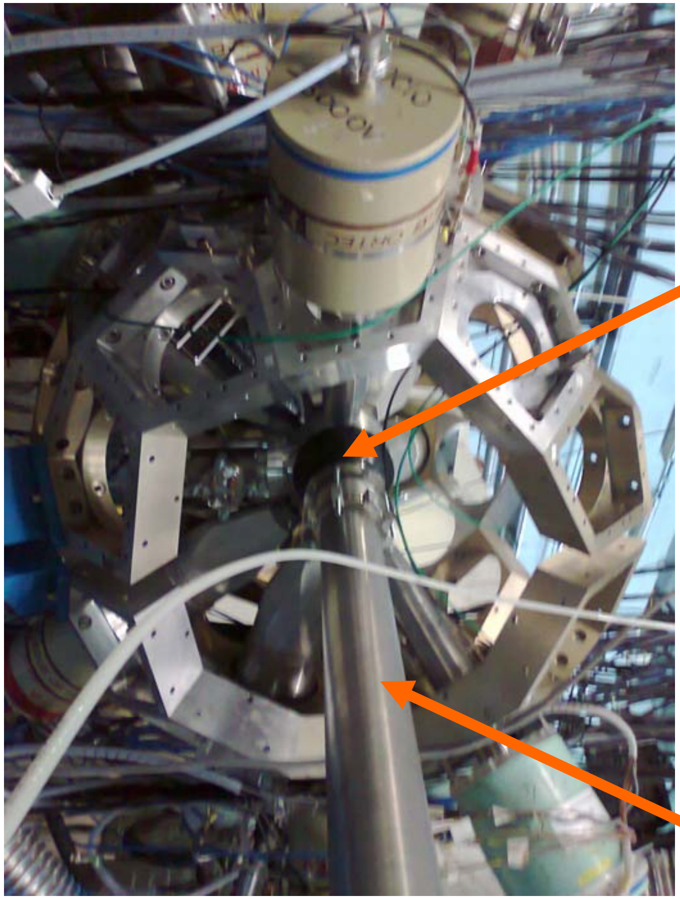
*13 Ge Detectors + BGO

- 1 Ge det. @ 47°
- 2 Ge det. @ 86°
- 4 Ge det. @ 94°
- 2 Ge det. @ 133°
- 4 Ge det. @ 157°

*Acquisition system :

- COMET-6X cards
- Narval software

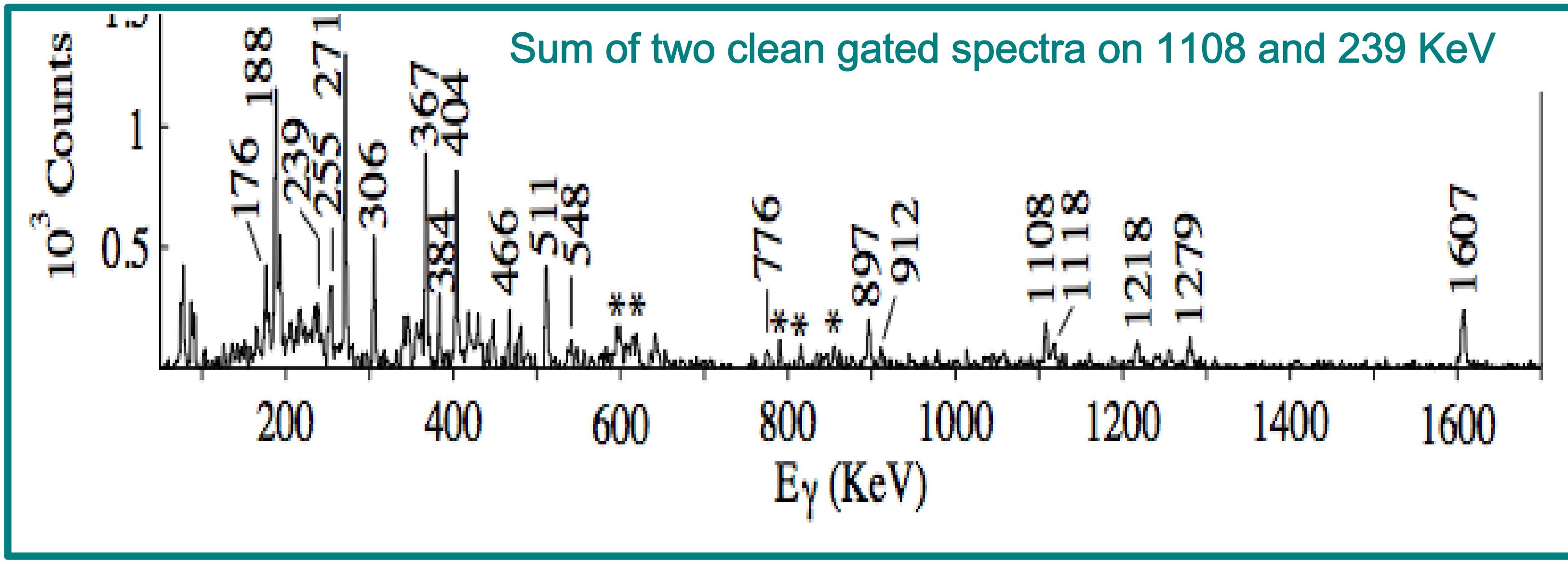
*Around 7.6 10^9 two- and higher fold γ coincidence events were recorded.



3. Data analysis

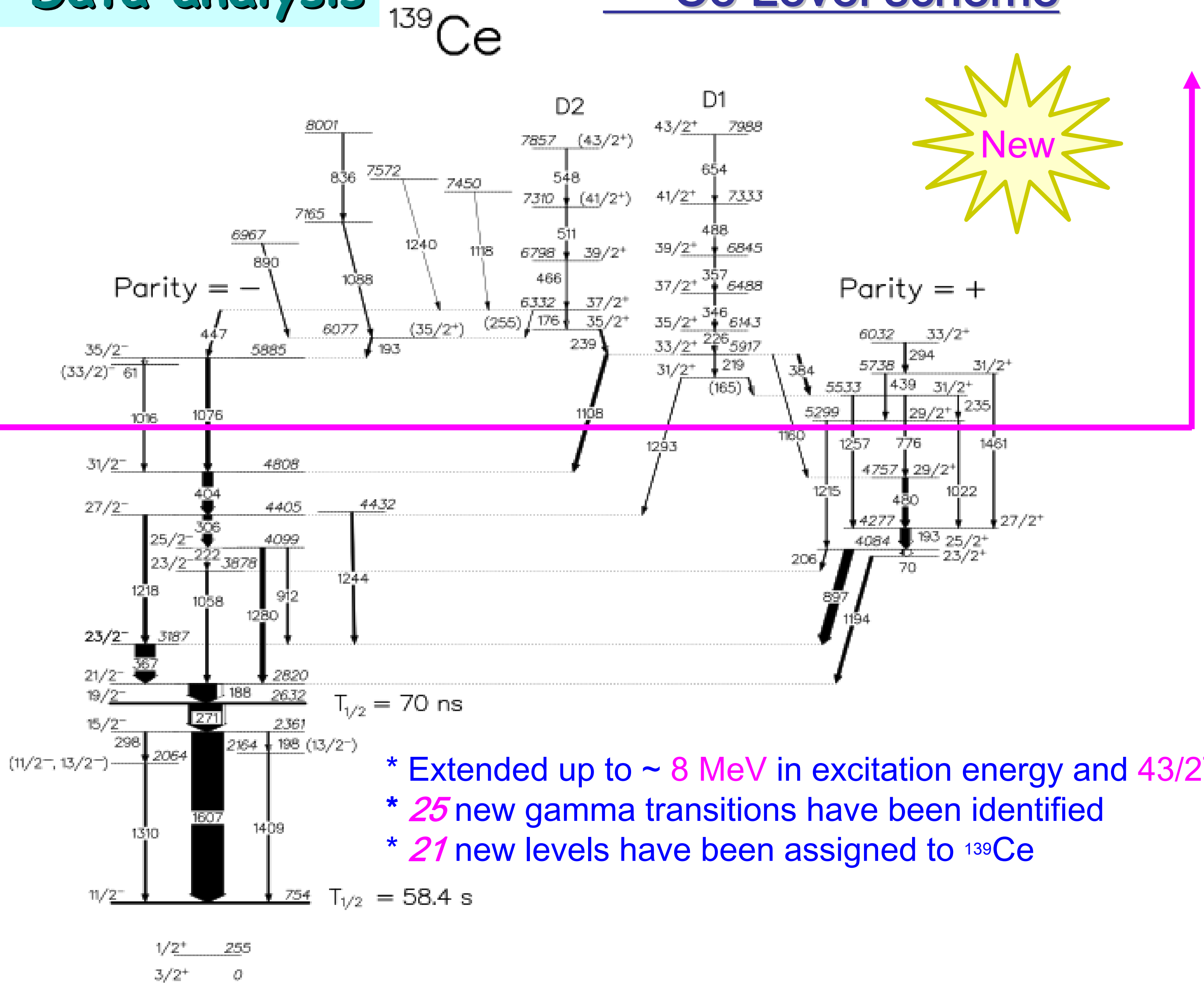
The analysis software "*Radware*"

* Sorting of several 4k x 4k total Eγ – Eγ matrices for different conditions
* Generating the gated coincidence spectra from the matrices
* And also their ANALYSIS



3. Data analysis

^{139}Ce Level scheme

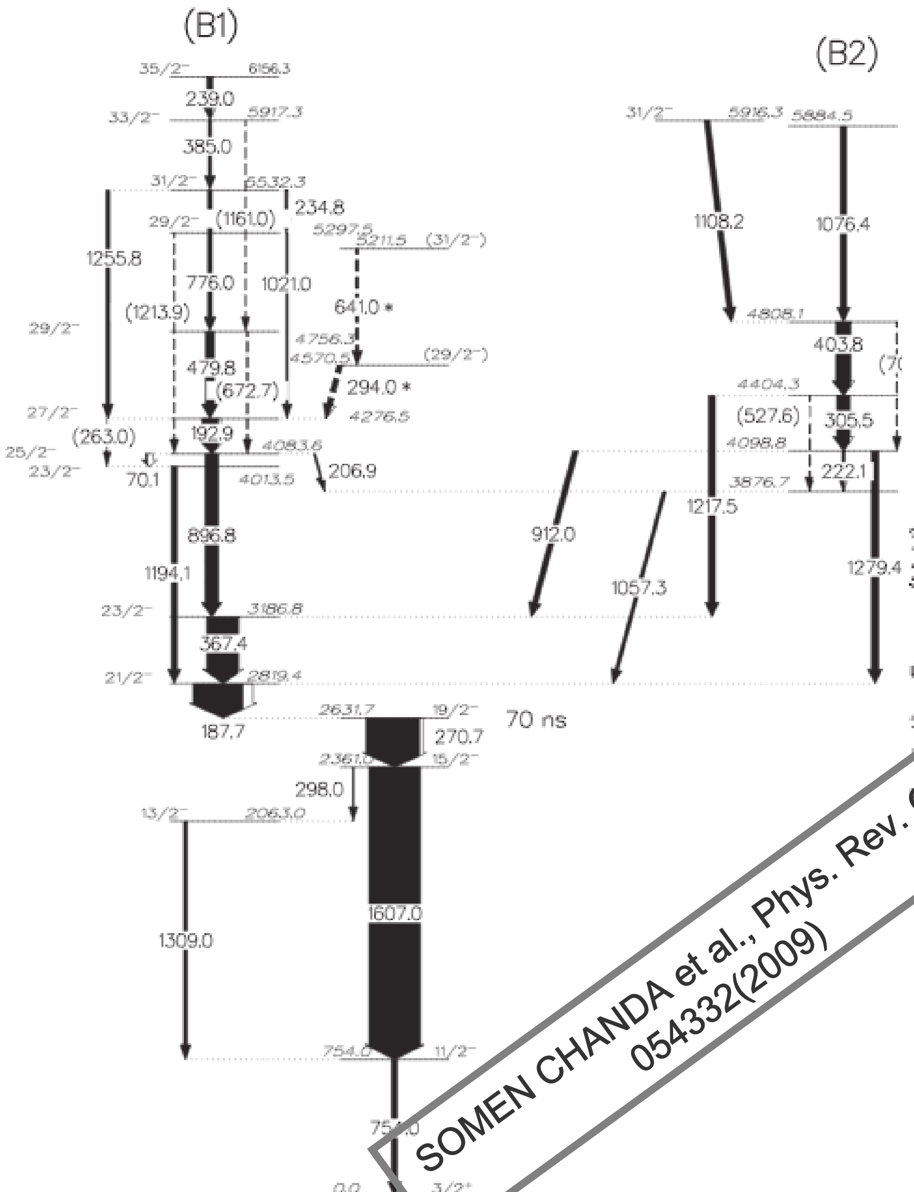


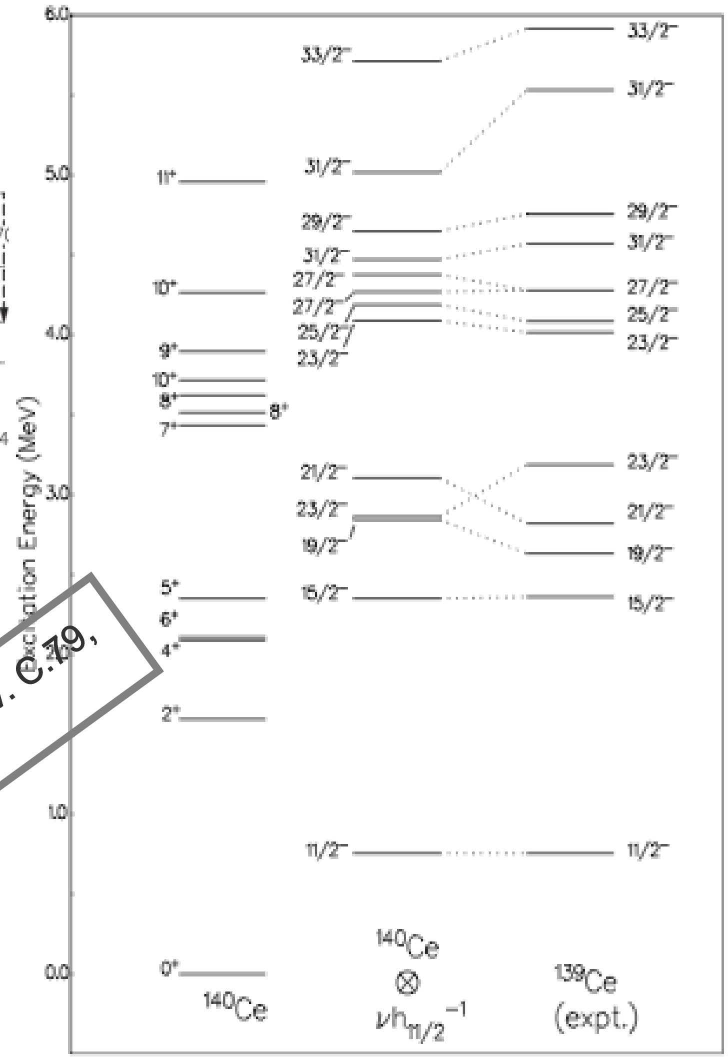
* Extended up to ~ 8 MeV in excitation energy and 43/2ℏ in spin
* *25* new gamma transitions have been identified
* *21* new levels have been assigned to ^{139}Ce

3. Data analysis

^{139}Ce

^{139} Ce Level scheme





SOMEN CHANDA et al., Phys. Rev. C 79, 054332(2009)

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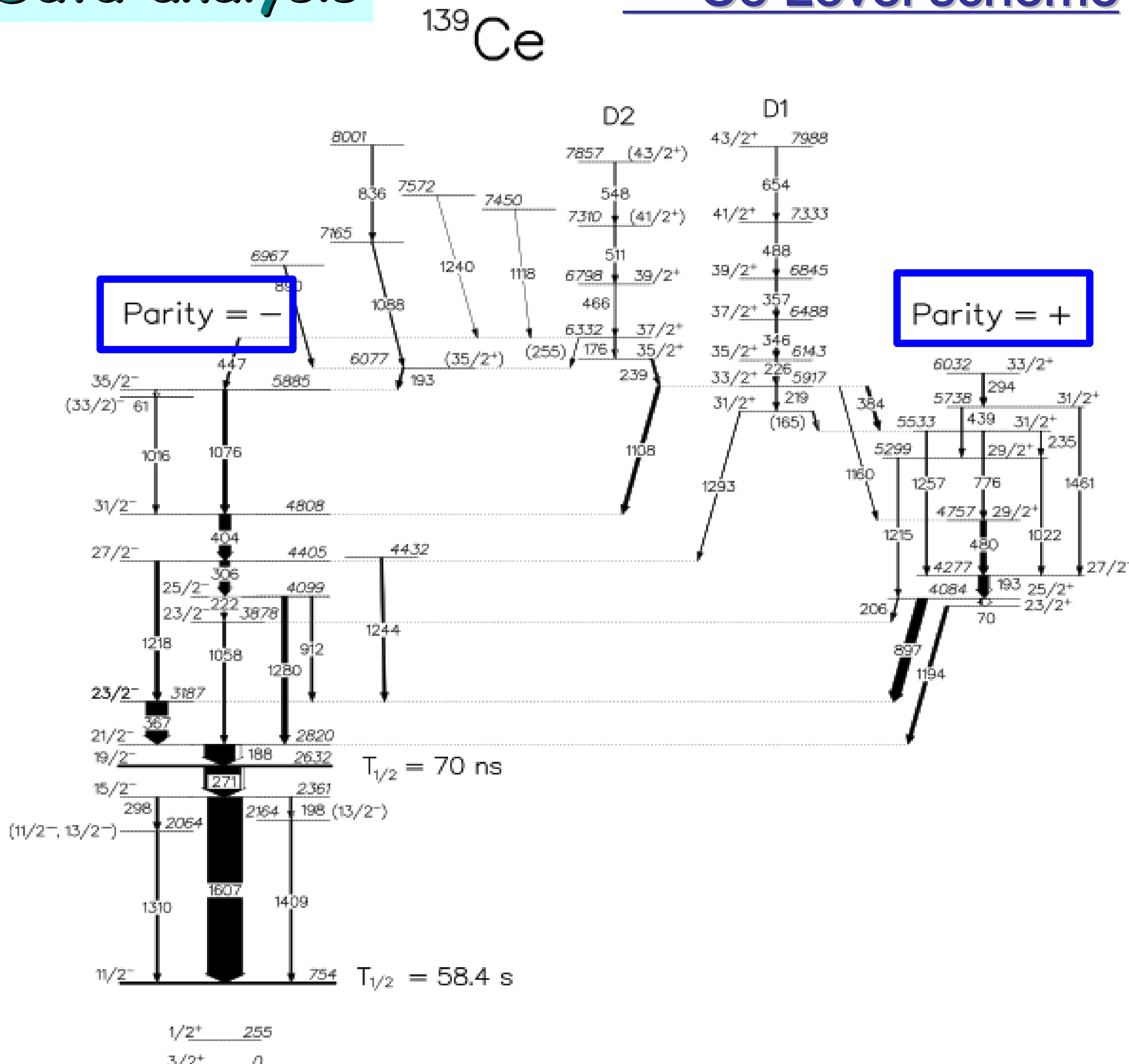
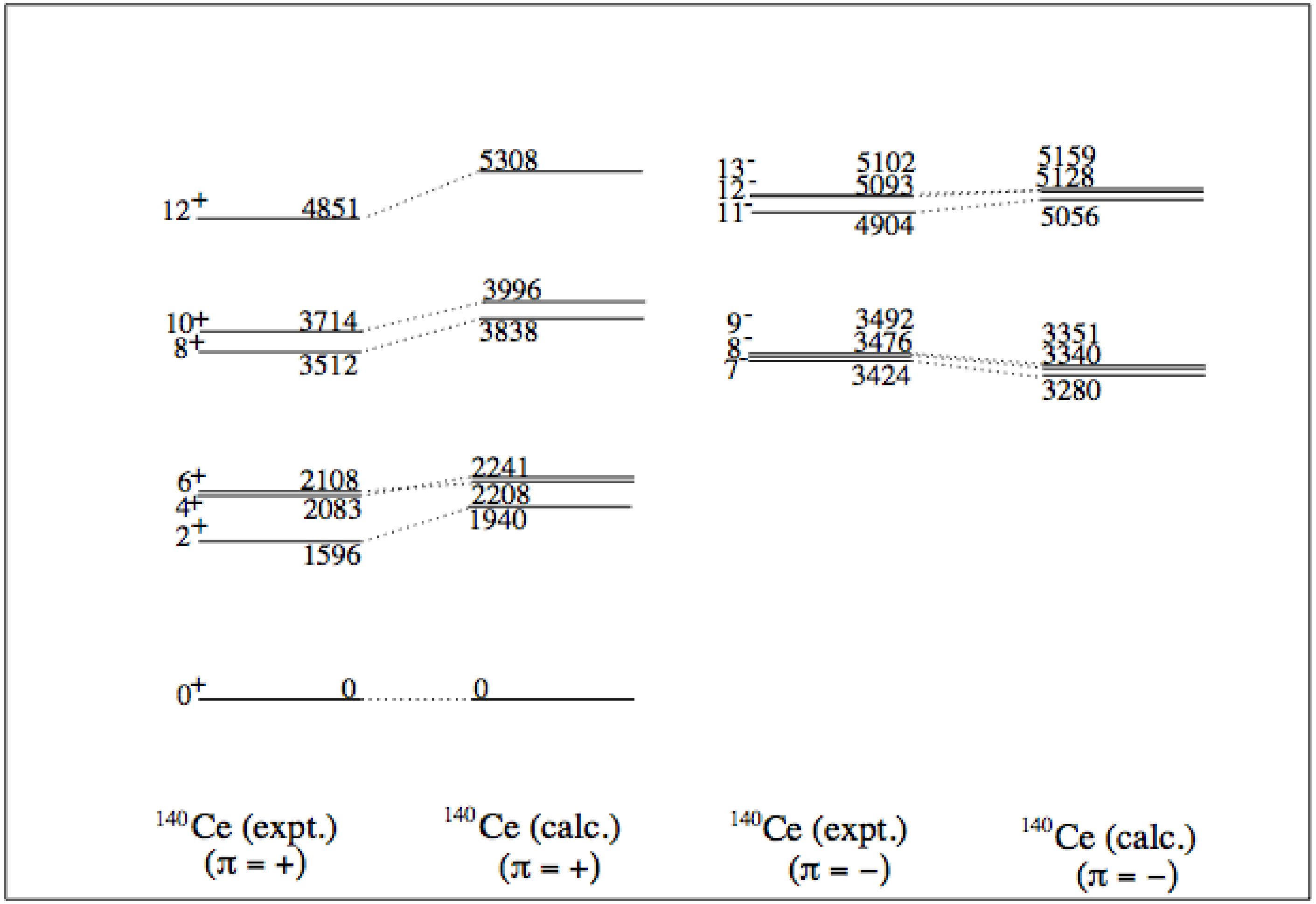


4. Theoretical interpretation

Shell Model calculation for ^{140}Ce



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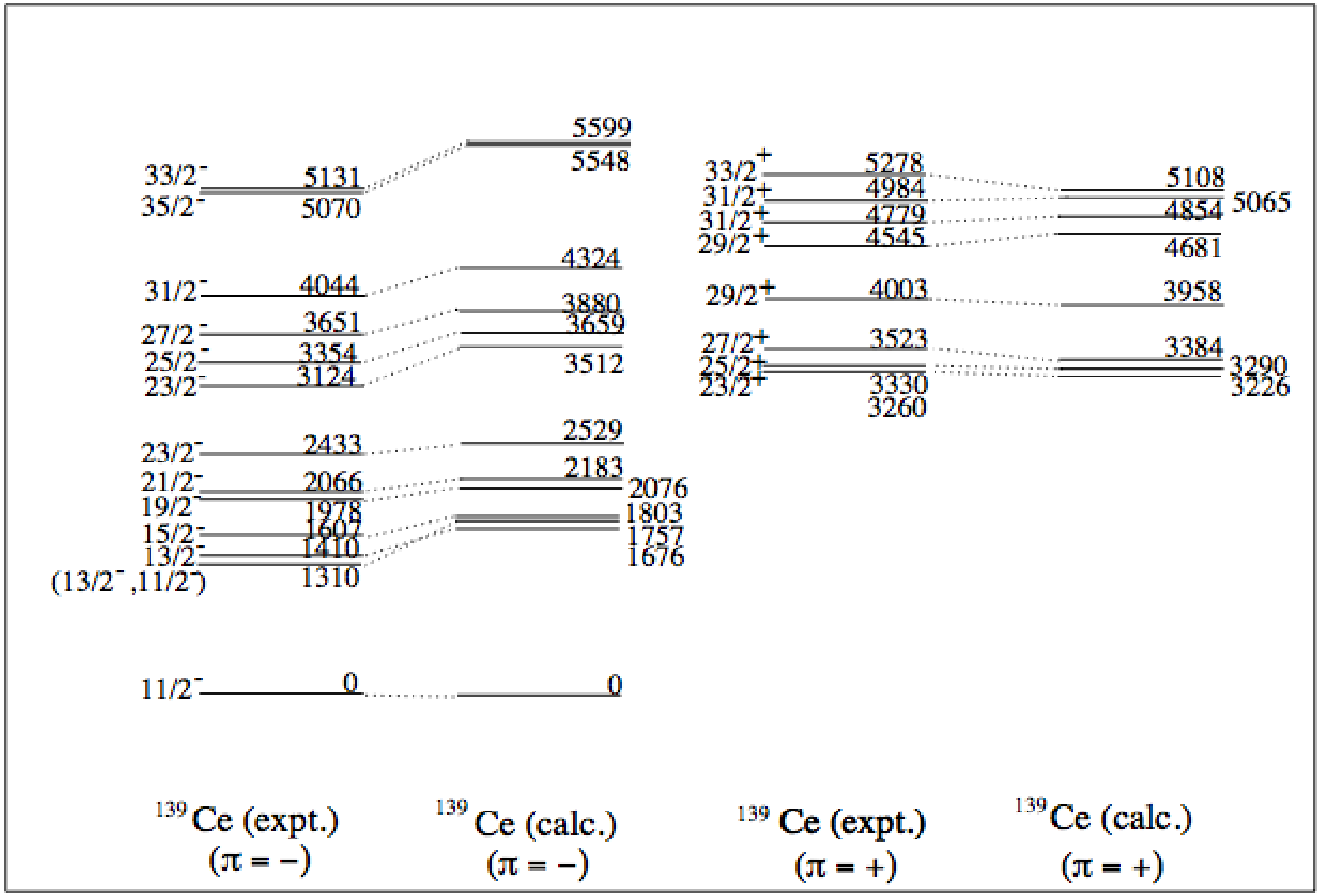
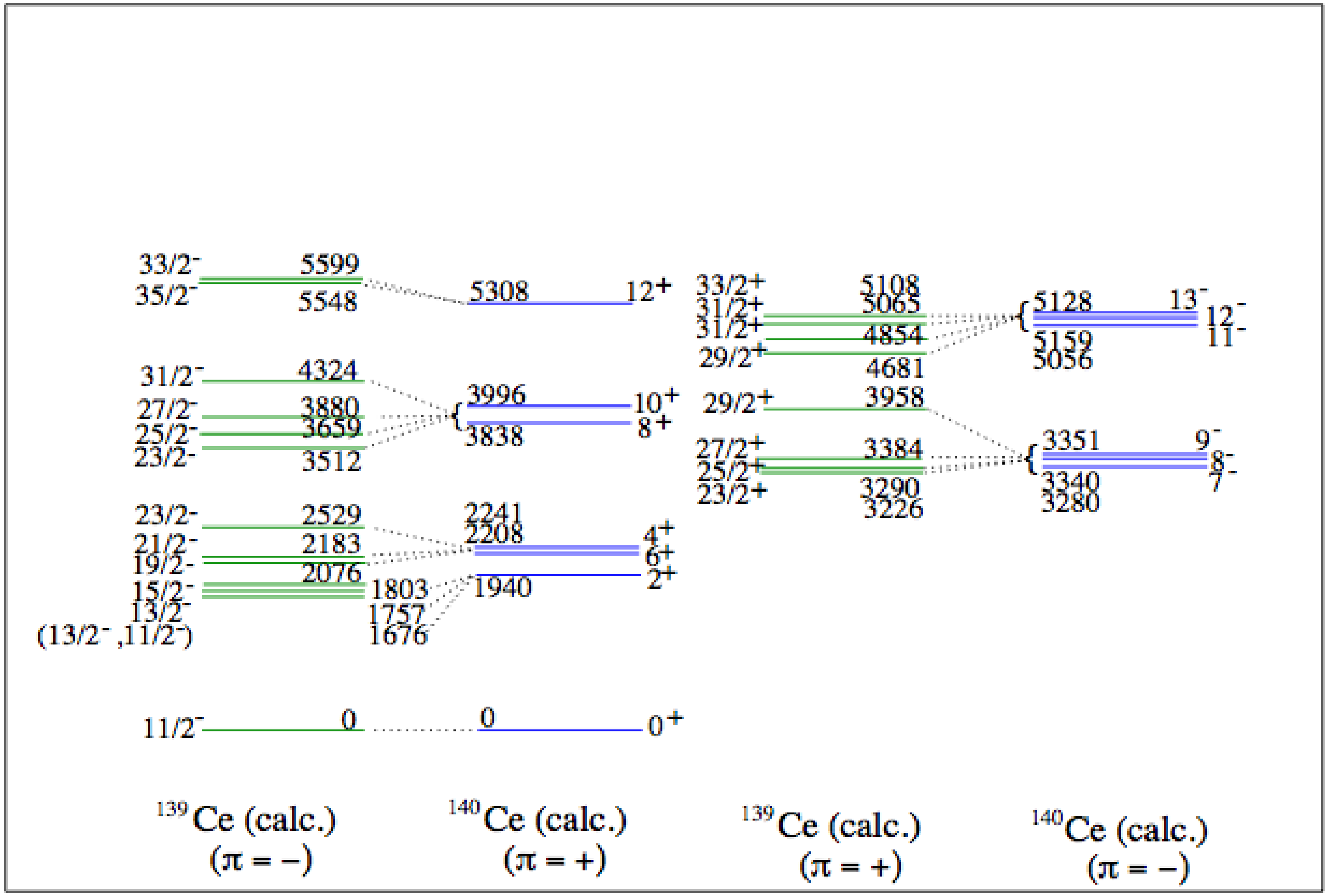


4. Theoretical interpretation

Shell Model calculation : ^{139}Ce and ^{140}Ce comparison



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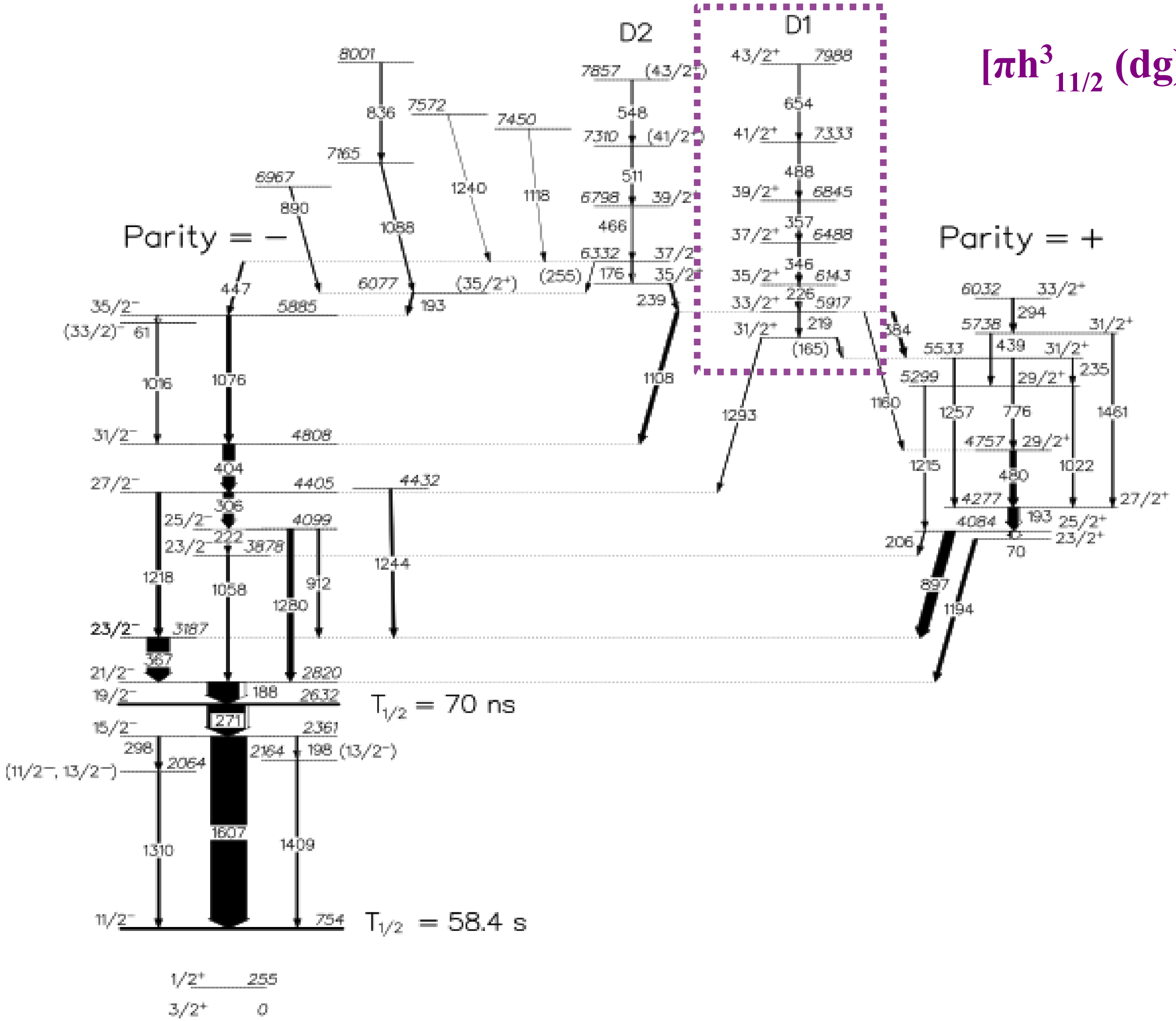
^{139}Ce Level scheme

^{139}Ce

$[\pi h^{3}_{11/2}\ (dg)^{1}]\otimes \nu h^{-1}_{11/2}$



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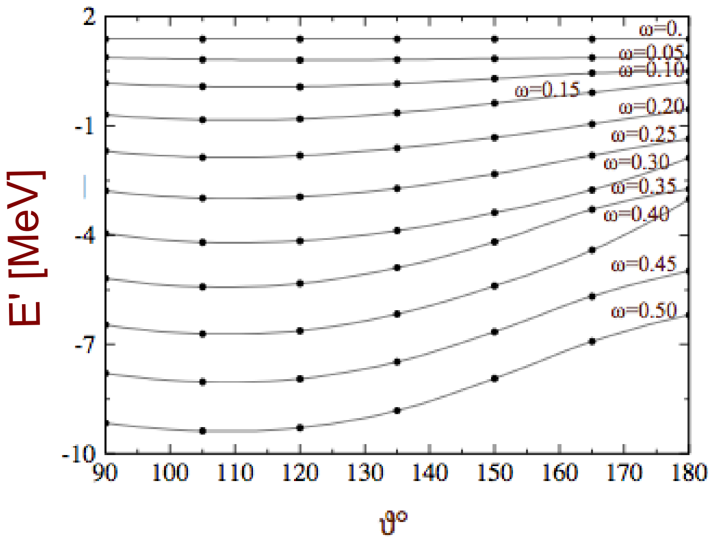


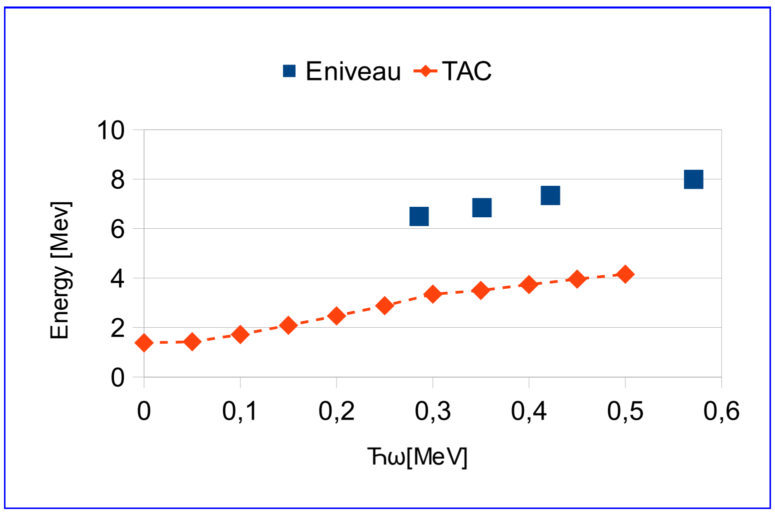
TAC

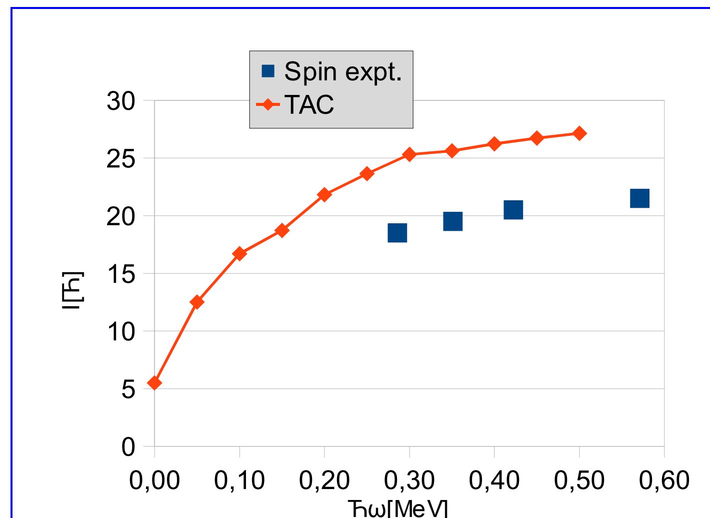
Tilted Axis Cranking

S. Frauendorf (1993)

$\pi[h^3_{11/2}\,(dg)^1] \otimes \nu h^{-1}_{11/2}$; $\varepsilon_2 = 0.1$, $\gamma = 0°$ From CNS

$\theta_{tilt} \approx 110°$





5. SUMMARY

- High spin states of ^{139}Ce are investigated via $^{14}C^{*}(^{130}Te,5n)^{139}Ce^{*}$ reaction.
- Multipolarities of the rays are deduced from DCO and anisotropy ratios measurements.
- The level scheme is extended up to 43/2ℏ in spin and 8 MeV in energy.
- Low-spin states are generated by one neutron hole coupled with ^{140}Ce core.
- High-spin states are based on the configurations formed by a combined contribution on neutron hole in $h_{11/2}$ and protons excitations to the orbital $h_{11/2}$
- The observed high spin states of (π =+) have the structure :
  $\pi[h^{3}_{11/2}\,(dg)^{1}]\otimes \nu h^{-1}_{11/2}$

ACKOWLEDGMENTS

A. Astier,[1] I. Deloncle,[1] T. Konstantinopoulos,[1]

J.M. Régis,[3] D. Wilmsen,[3] B. Melon,[4] A. Nannini,[4] C. Ducoin,[5] D. Guinet,[5]
T. Bhattacharjee,[6] A. Gargano,[7] and L. Coraggio,[7] N. Itaco,[7]

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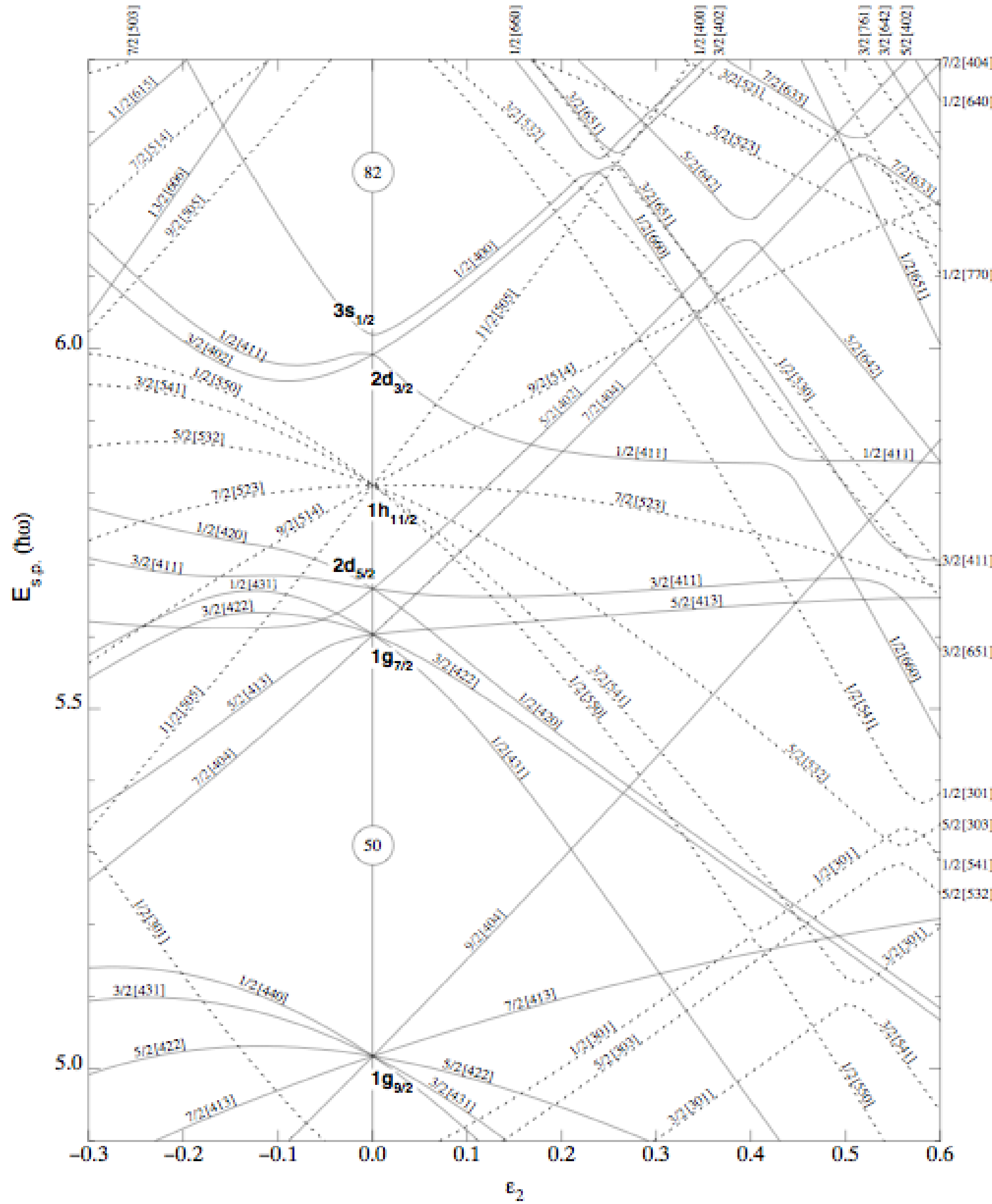


Figure 11. Nilsson diagram for protons, $50 \leq Z \leq 82$ ($\varepsilon_4 = \varepsilon_2^2/6$).

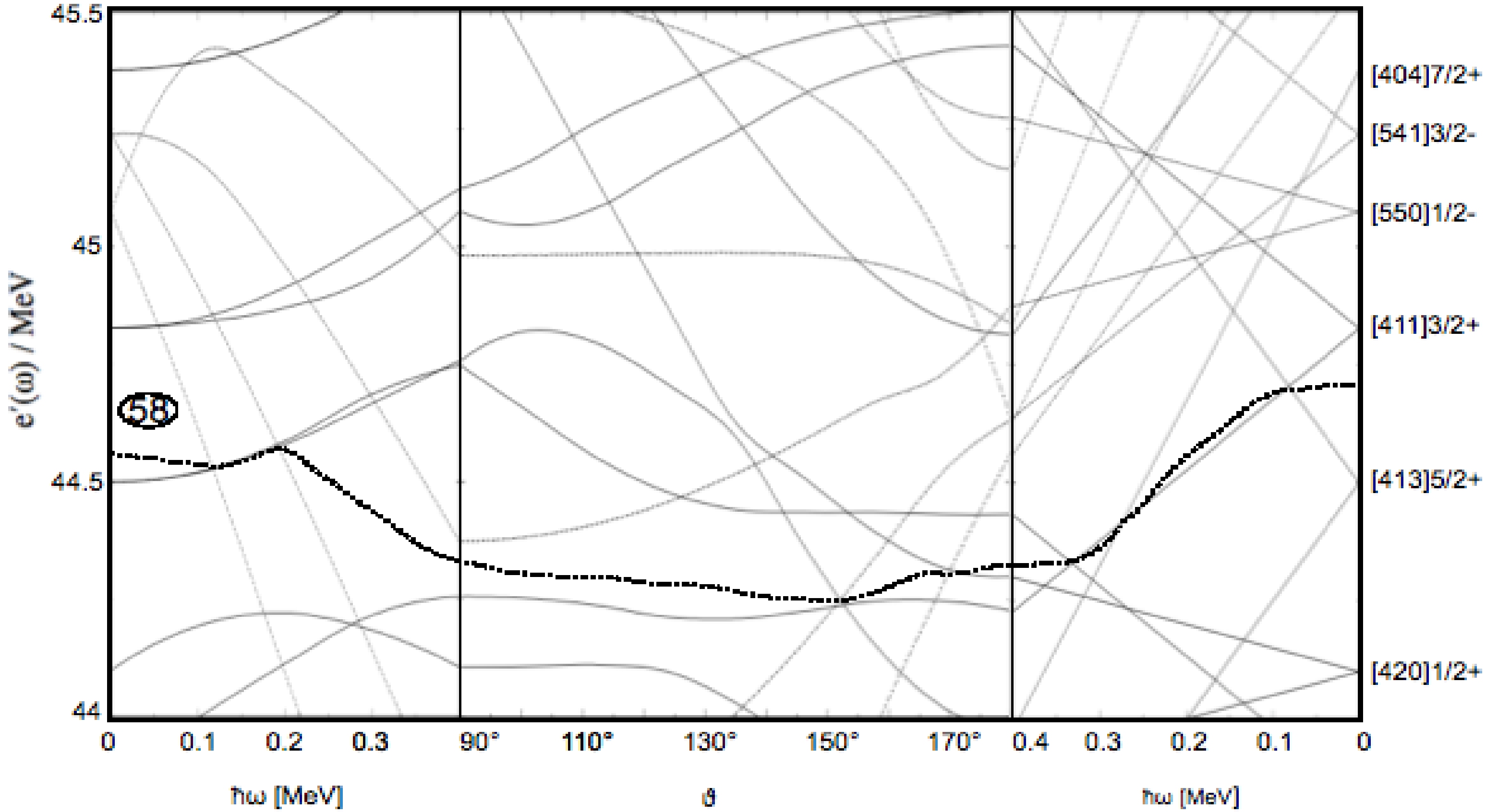


Fig.1 Single proton energies for $\varepsilon_2 = 0.1$, $\gamma = 0°$

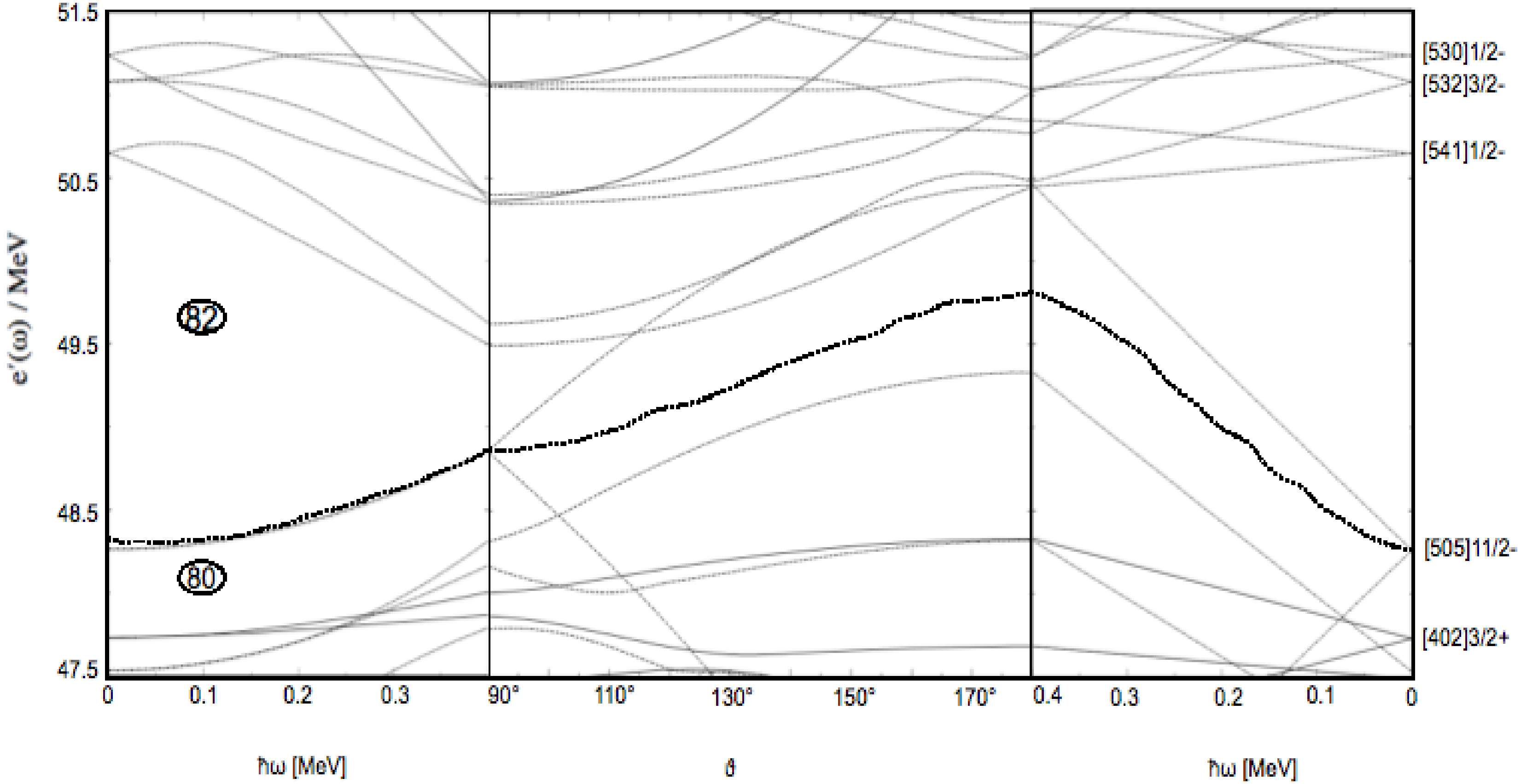
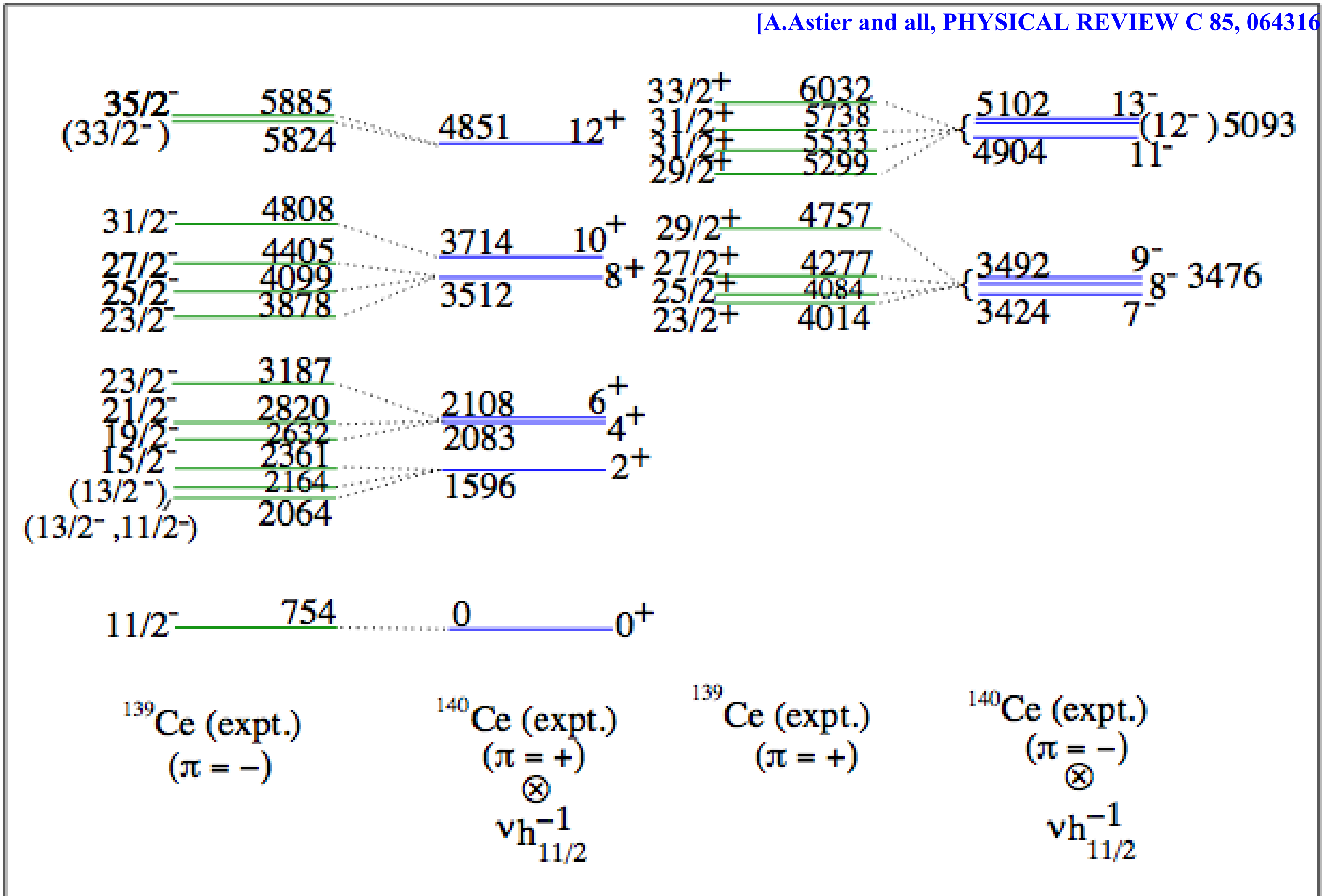


Fig.2 Single neutron energies for $\varepsilon_2 = 0.1$, $\gamma = 0°$

3. Data analysis

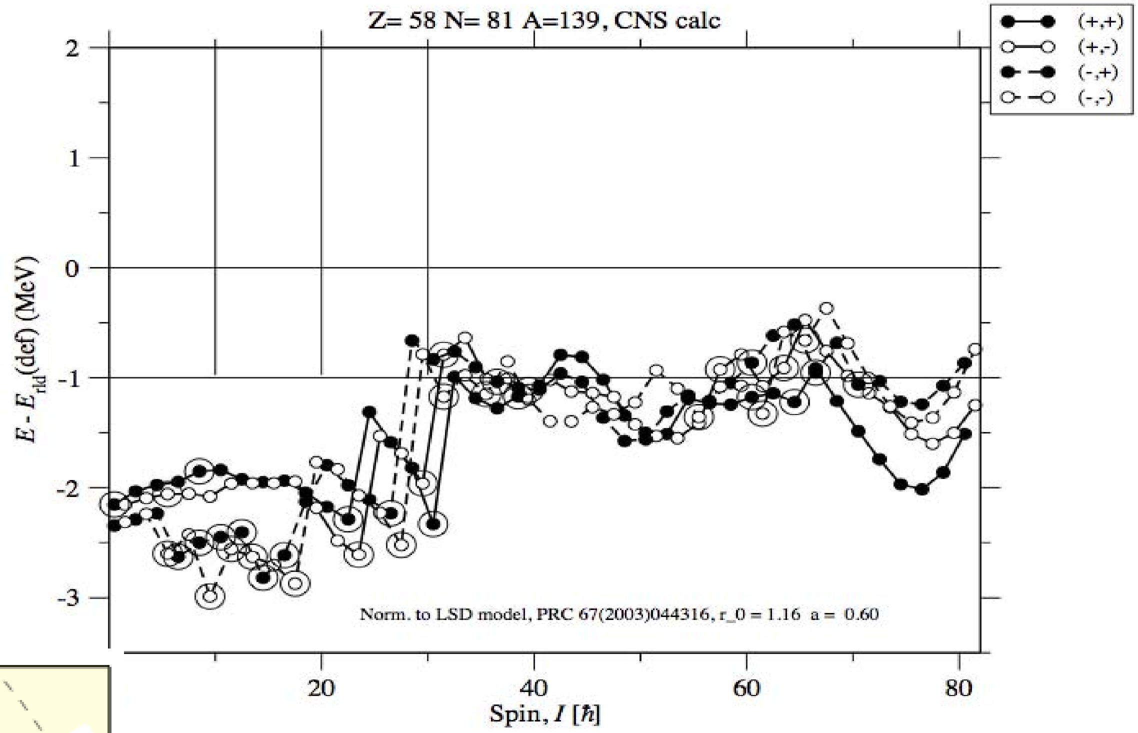
A core coupled neutron hole configuration [J. Ludziejewski and H. Arnold, Z. Phys. A 281, 287 (1977)]

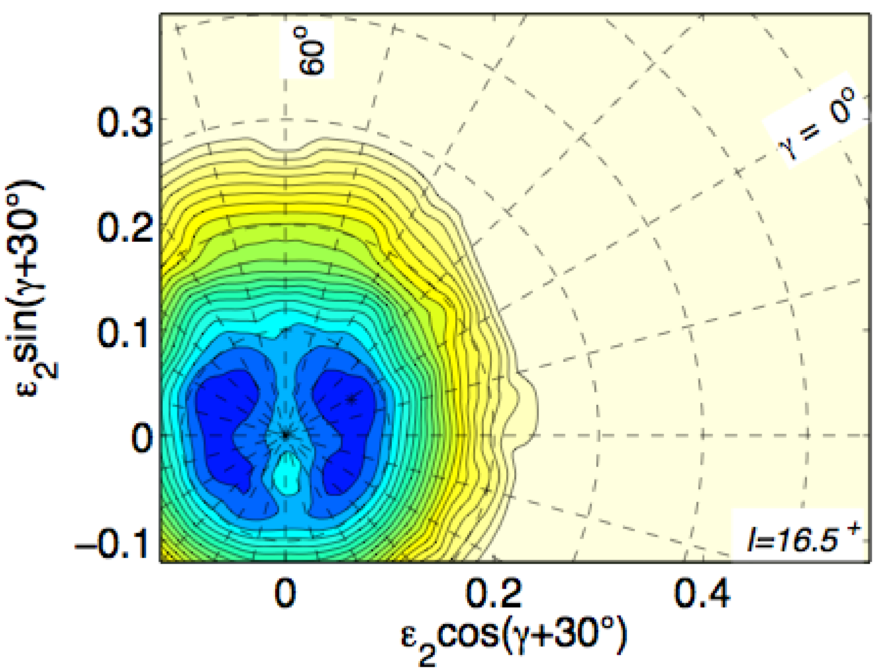


4. Theoretical interpretation

1. CNS

Cranked Nilson-Strutinsky

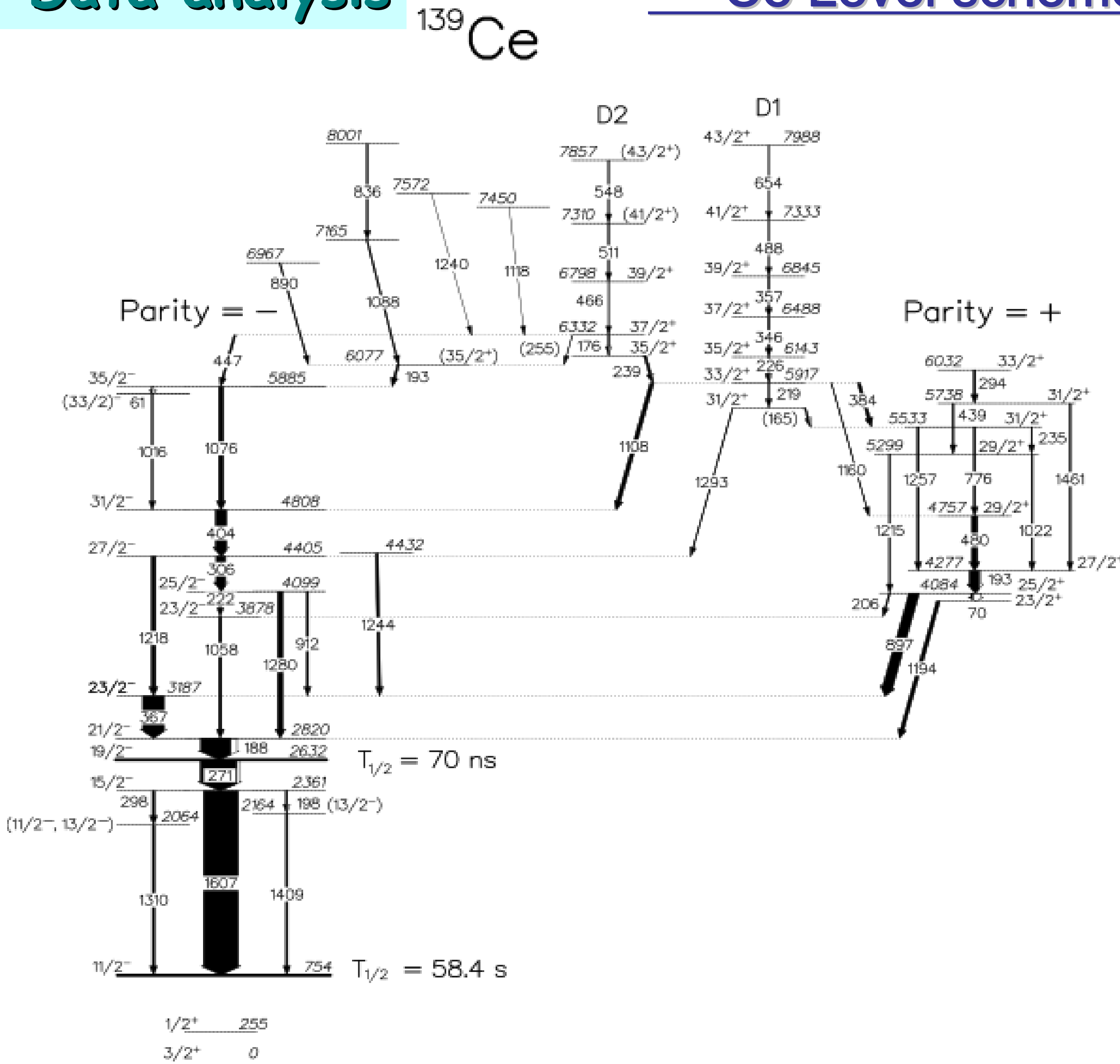




$\varepsilon_2 = 0.1\ ;\ \gamma = 0°$

3. Data analysis

^{139} Ce Level scheme



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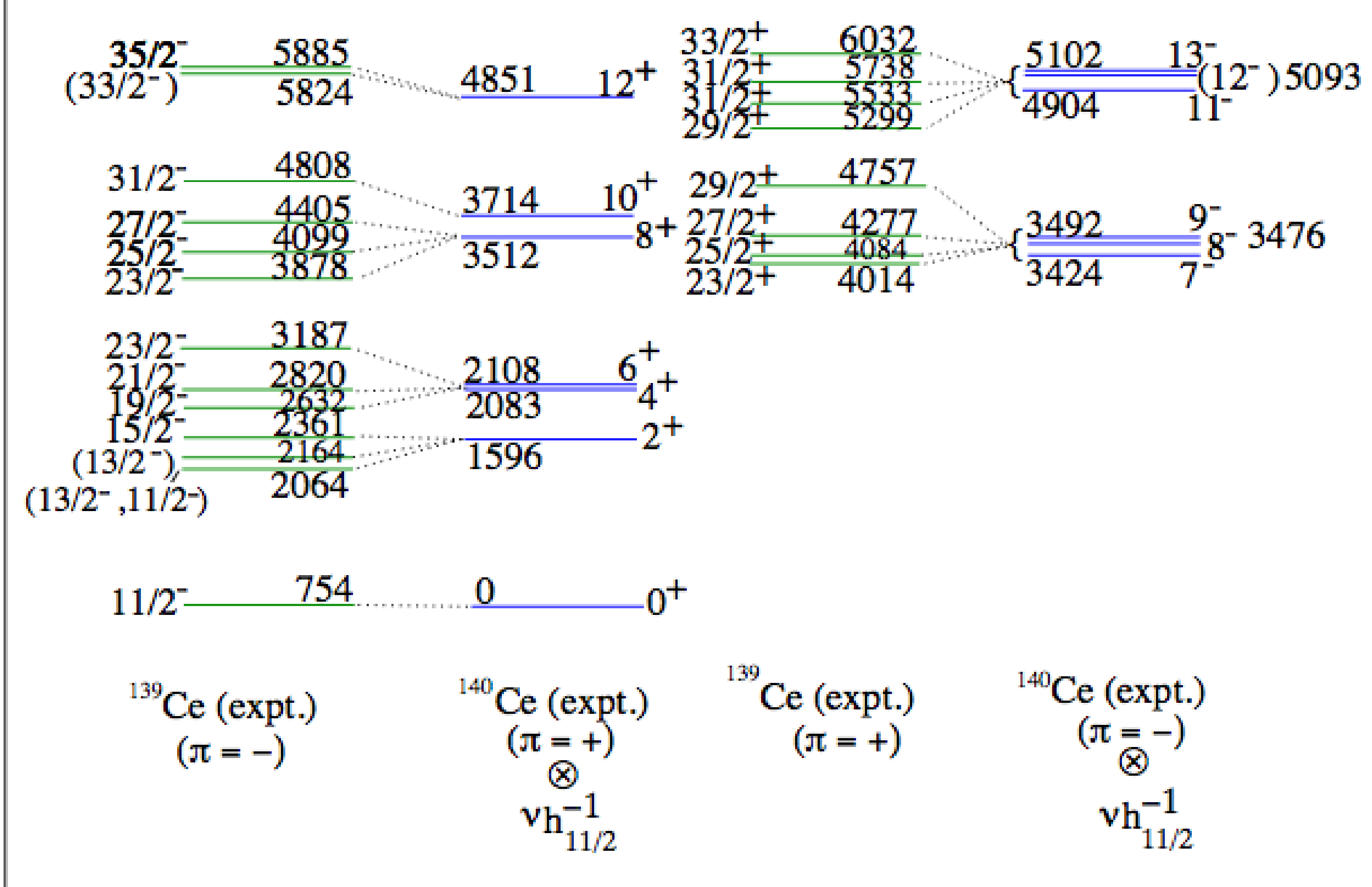
[A.Astier and all, PHYSICAL REVIEW C 85, 064316 (2012)]



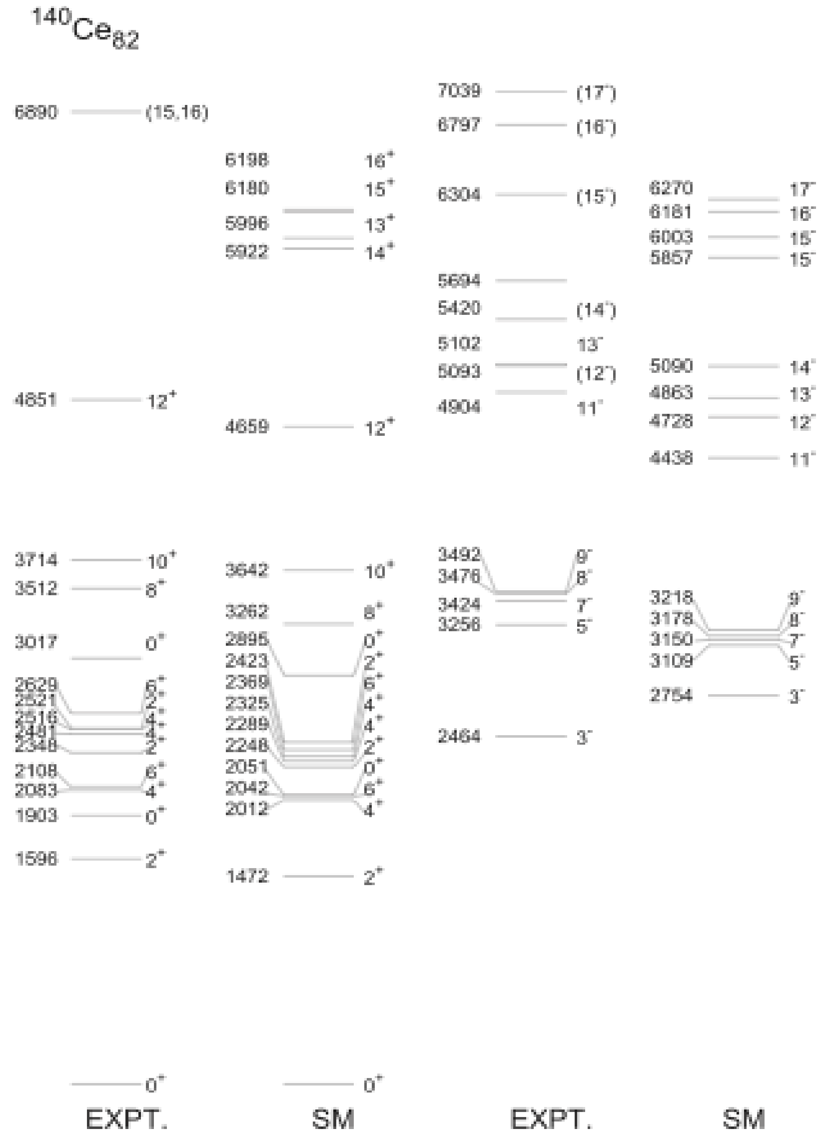
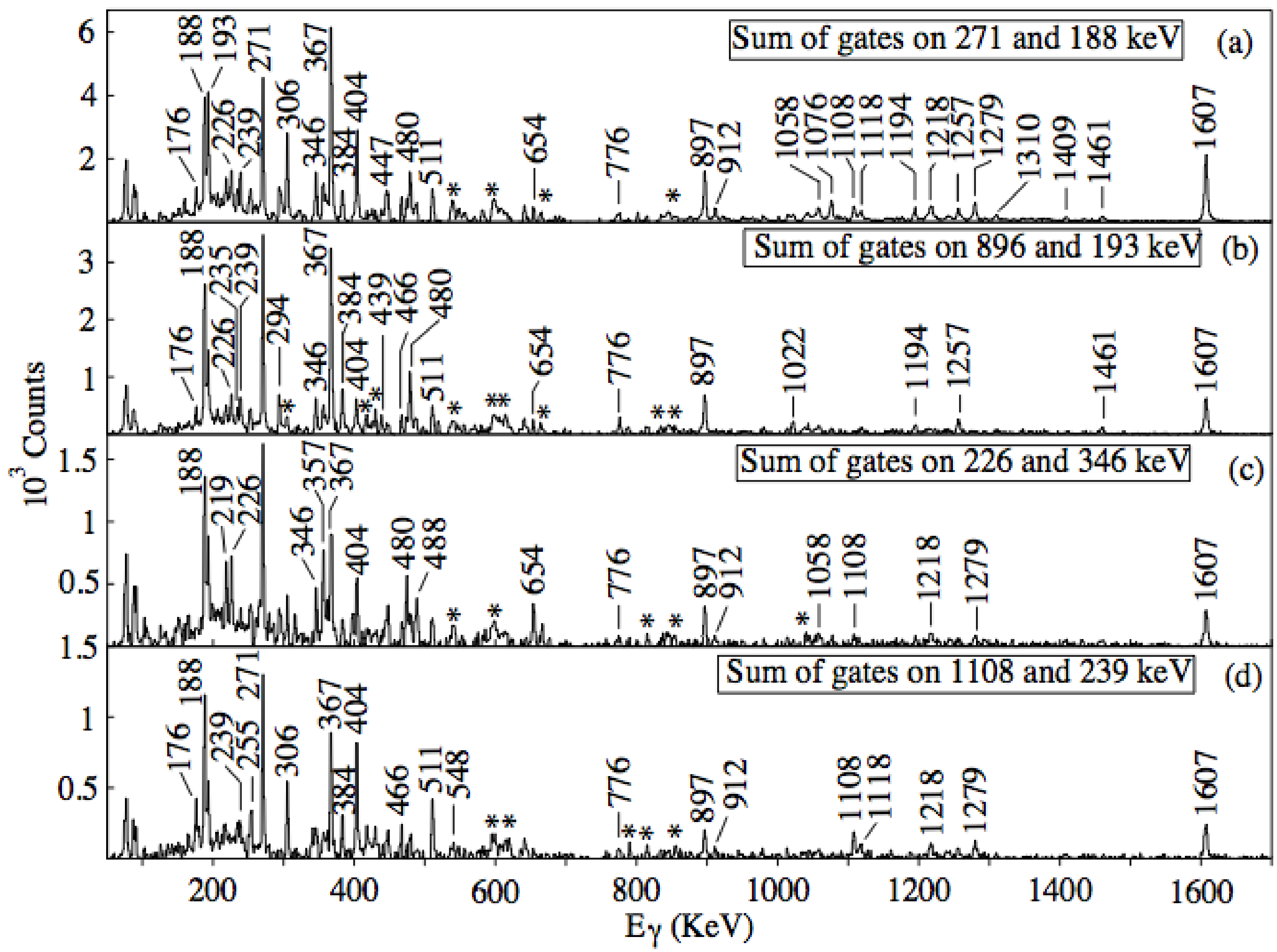
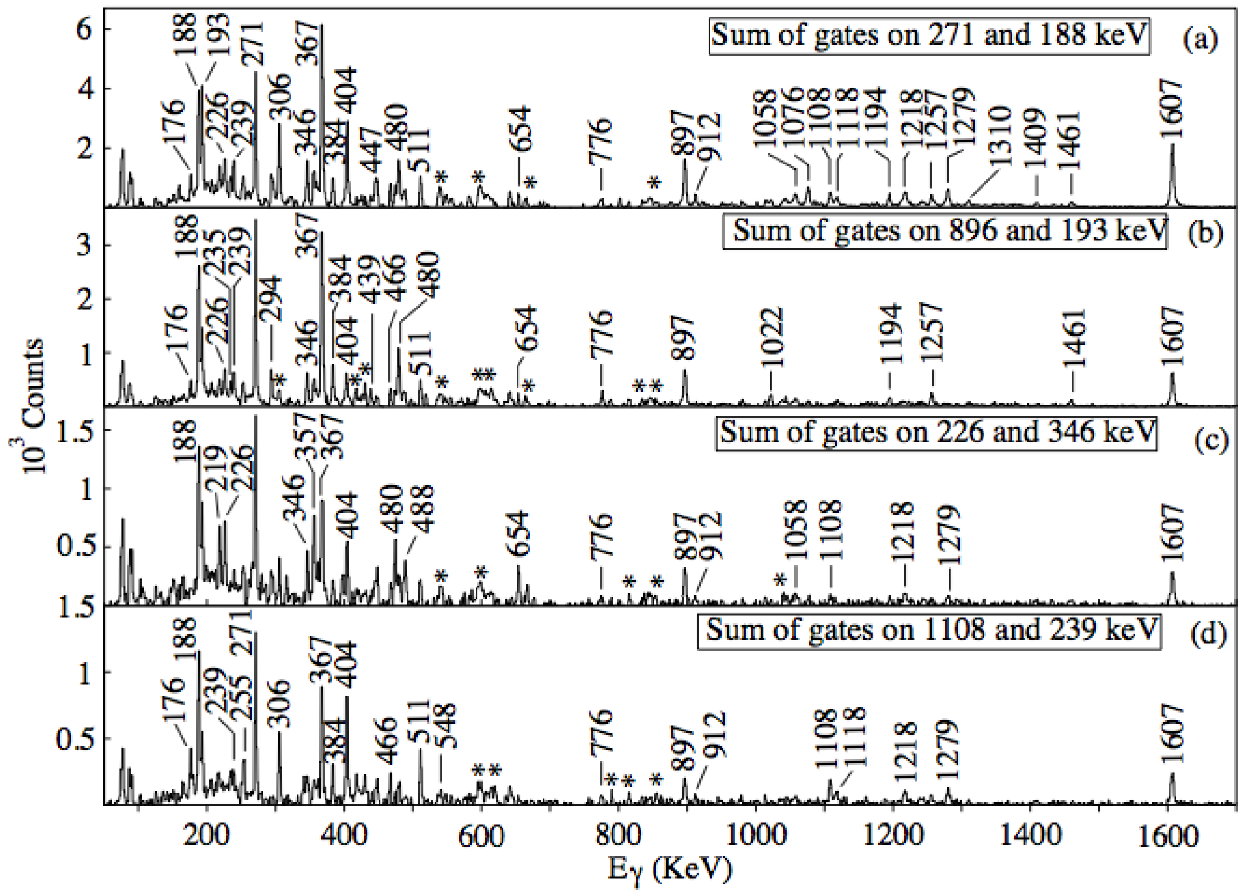


Figure 6. Comparison of experimental [6, 15] and calculated excitation spectra for ^{140}Ce using SN100PN interaction.


Sum of gates on 271 and 188 keV
(a)
176 188 193 226 239 271 306 346 367 384 404 447 480 511 654 776 897 912 1058 1076 1108 1118 1194 1218 1257 1279 1310 1409 1461 1607
Sum of gates on 896 and 193 keV
(b)
176 188 226 235 239 294 346 367 384 404 439 466 480 511 654 776 897 1022 1194 1257 1461 1607
Sum of gates on 226 and 346 keV
(c)
188 219 226 346 357 367 404 480 488 654 776 897 912 1058 1108 1218 1279 1607
Sum of gates on 1108 and 239 keV
(d)
176 188 239 255 271 306 367 384 404 466 511 548 776 897 912 1108 1118 1218 1279 1607
10³ Counts
Eγ (KeV)
200 400 600 800 1000 1200 1400 1600


Sum of gates on 271 and 188 keV
(a)
Sum of gates on 896 and 193 keV
(b)
Sum of gates on 226 and 346 keV
(c)
Sum of gates on 1108 and 239 keV
(d)
176
188
193
226
239
271
306
346
367
384
404
447
480
511
654
776
897
912
1058
1076
1108
1118
1194
1218
1257
1279
1310
1409
1461
1607
235
294
439
466
1022
219
357
488
255
548
10^3 Counts
Eγ (KeV)
200
400
600
800
1000
1200
1400
1600

3. Data analysis

R_{DCO} and Anisotropy R_θ measurements

* Multipolarities of the observed transitions were deduced from the measured DCO ratios and Anisotropy ratios R_θ.

  * The $R_{DCO} = I\gamma\ (FB, 90°) / I\gamma\ (90°, FB)$
  * The Anisotropy ratio $R_\theta = I\gamma\ (FB, all) / I\gamma\ (90°, all)$

* We have followed these rules :

For transitions and gates having same multi-polarities, $R_{DCO} = 1$

- M1 transition in E2 gate, $R_{DCO} = 0.5$
- E2 transition in M1 gate, $R_{DCO} = 2$
- Anisotropy $R_\theta = 0.68$ for M1 transition and $= 1$ for E2 transition

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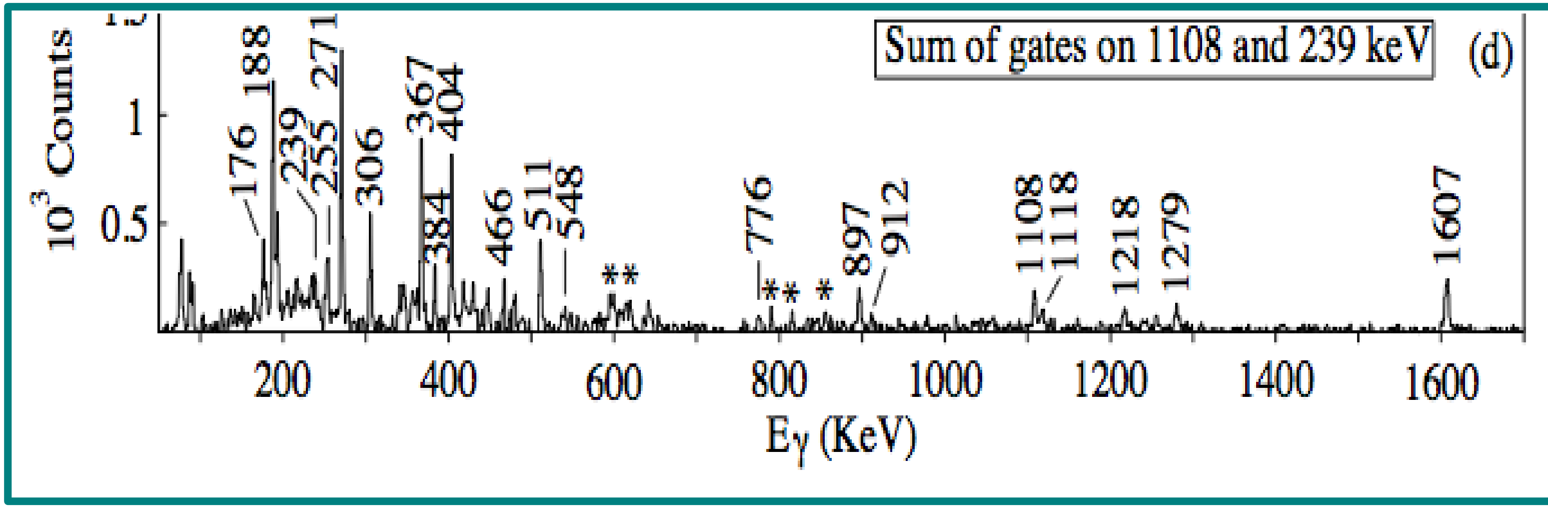
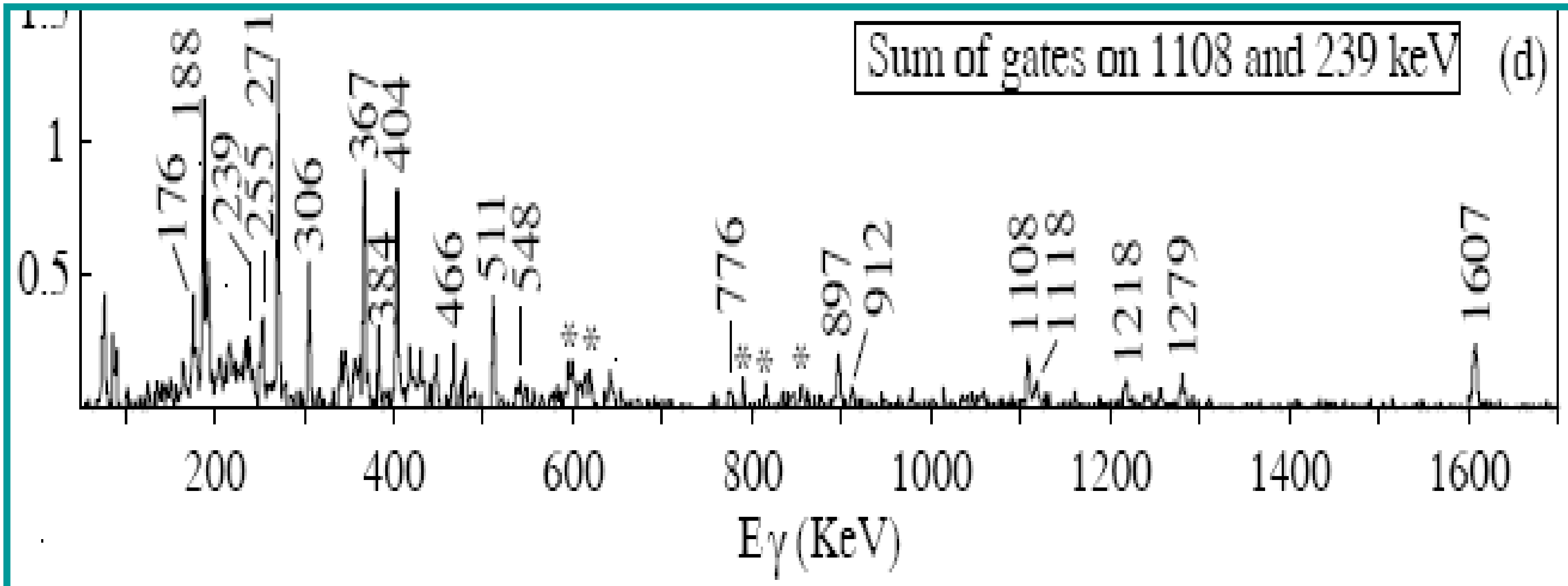
2. Experiment description
3. Data analysis
4. Theoretical interpretation
5. Summary



Sum of gates on 1108 and 239 keV
(d)
10^3 Counts
0.5
1
176
188
239
255
271
306
367
384
404
466
511
548
776
897
912
1108
1118
1218
1279
1607
200
400
600
800
1000
1200
1400
1600
Eγ (KeV)



Sum of gates on 1108 and 239 keV
(d)
0.5
1
176
188
239
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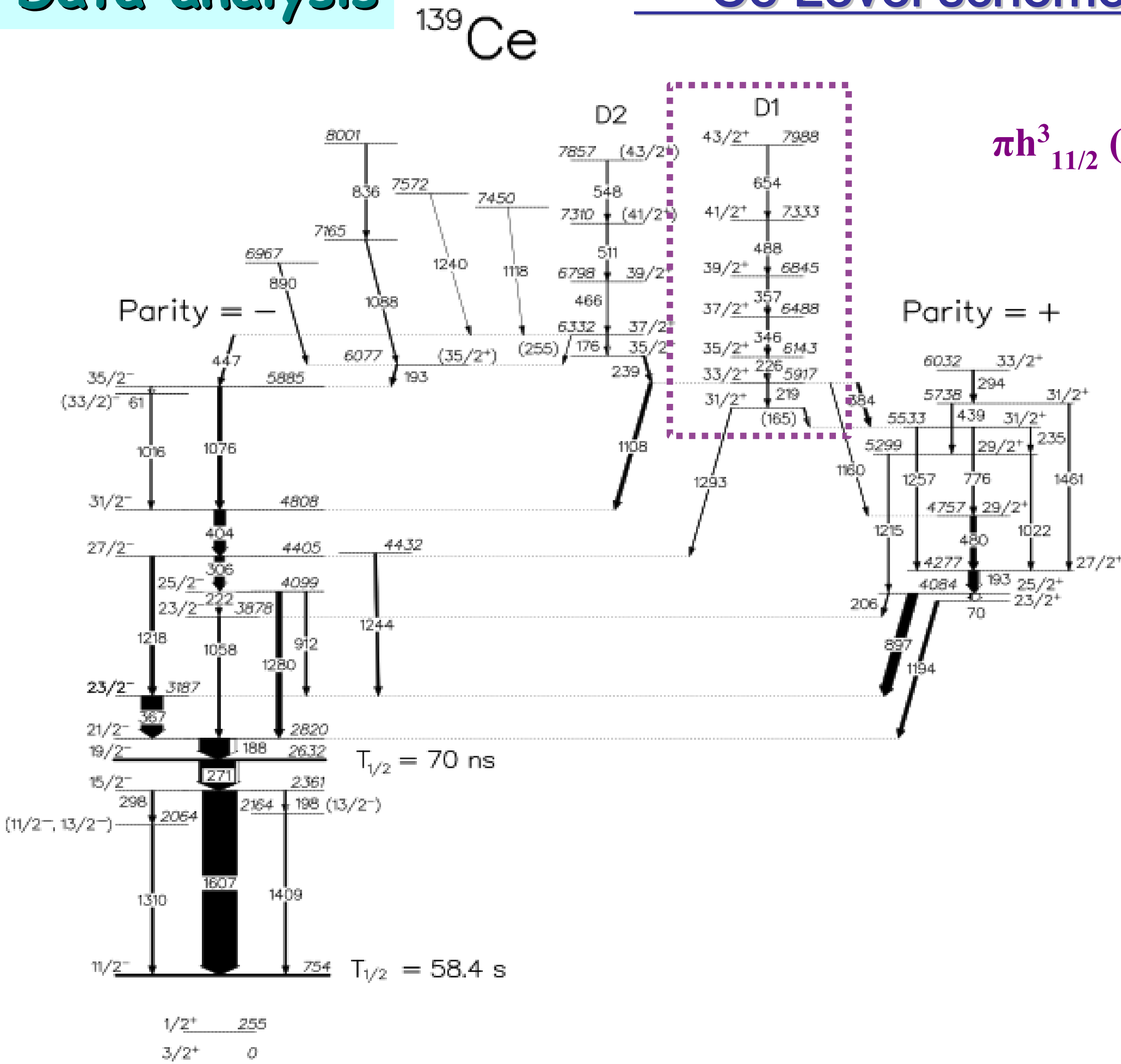
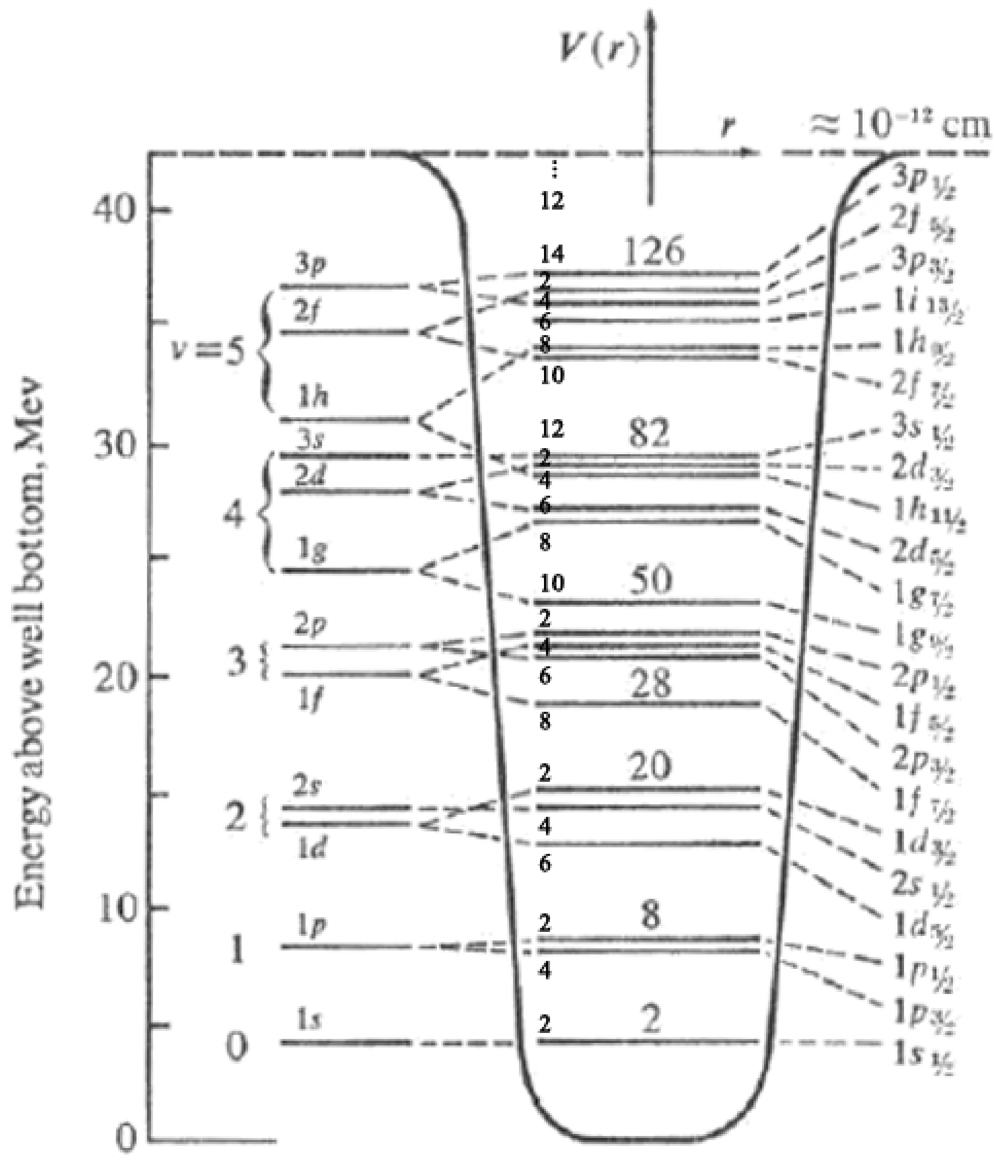
1400
1600
Eγ (KeV)

3. Data analysis

^{139} Ce Level scheme



$\pi h^3_{11/2}\ (dg)^1 \otimes \nu h^{-1}_{11/2}$



V(r)
r
≈ 10⁻¹² cm
Energy above well bottom, Mev
40
30
20
10
0
v = 5
4
3
2
1
0
3p
2f
1h
3s
2d
1g
2p
1f
2s
1d
1p
1s
12
14
2
4
6
8
10
12
2
4
6
8
10
2
4
6
8
2
4
6
2
4
2
126
82
50
28
20
8
2
3p 1/2
2f 5/2
3p 3/2
1i 13/2
1h 9/2
2f 7/2
3s 1/2
2d 3/2
1h 11/2
2d 5/2
1g 7/2
1g 9/2
2p 1/2
1f 5/2
2p 3/2
1f 7/2
1d 3/2
2s 1/2
1d 5/2
1p 1/2
1p 3/2
1s 1/2

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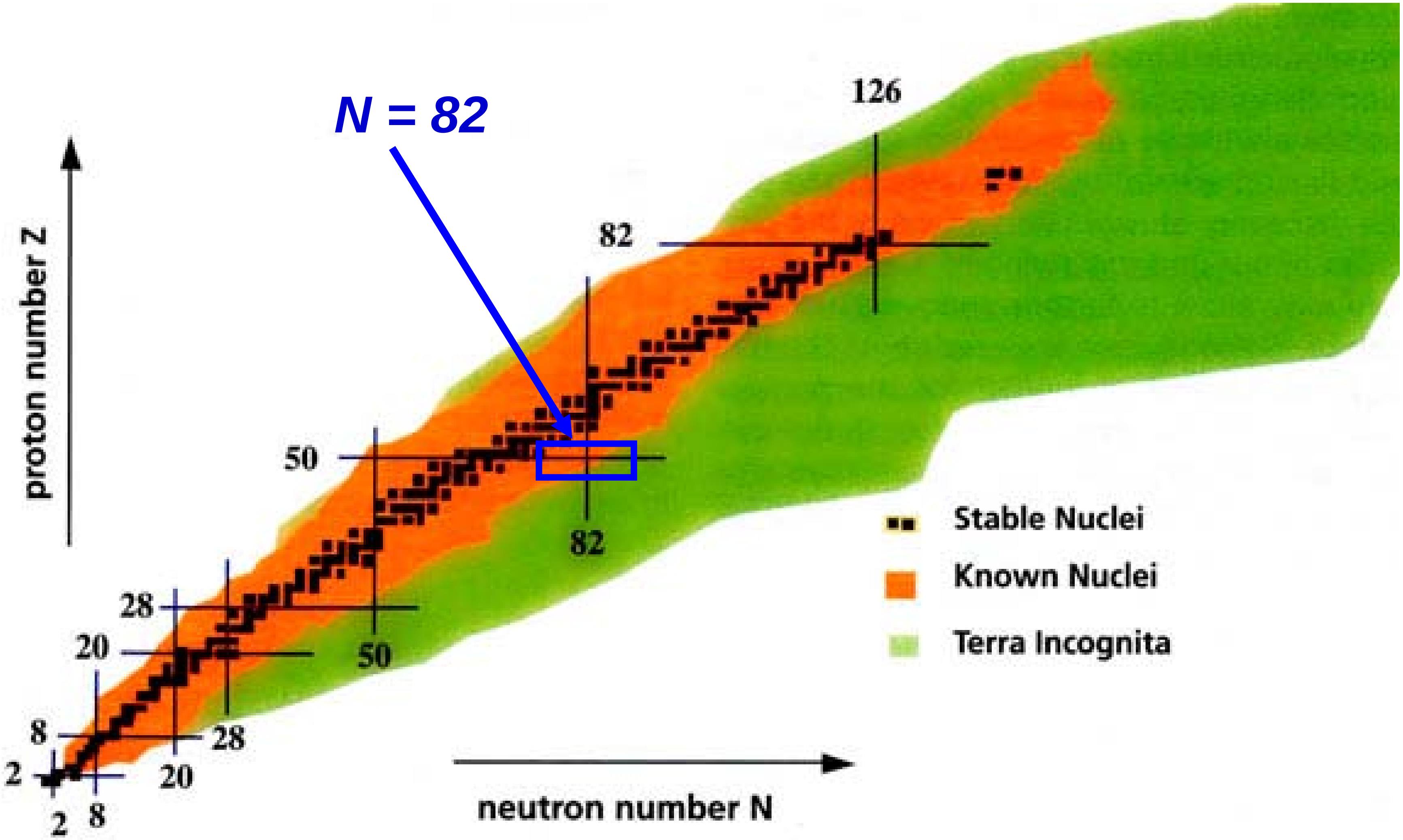

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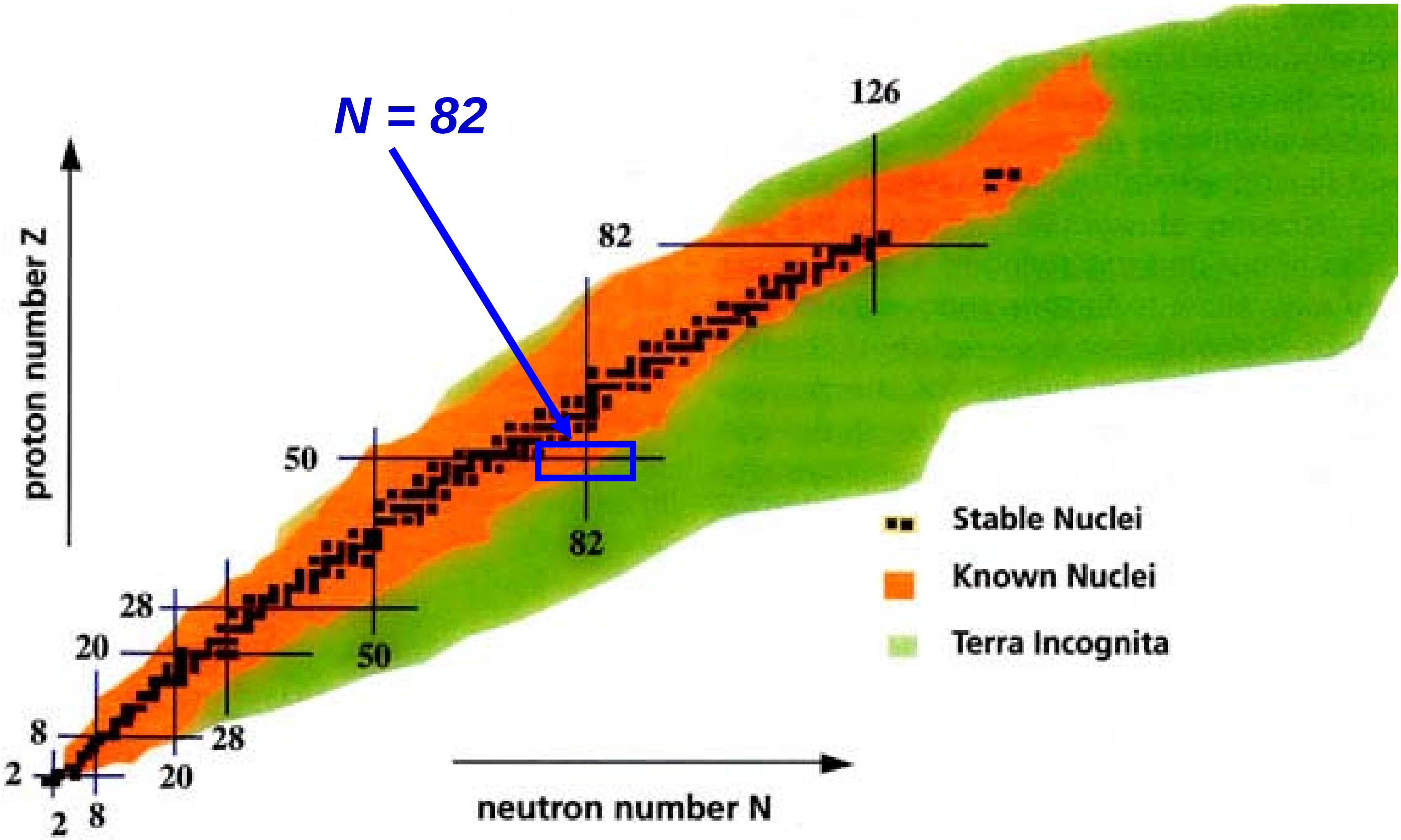

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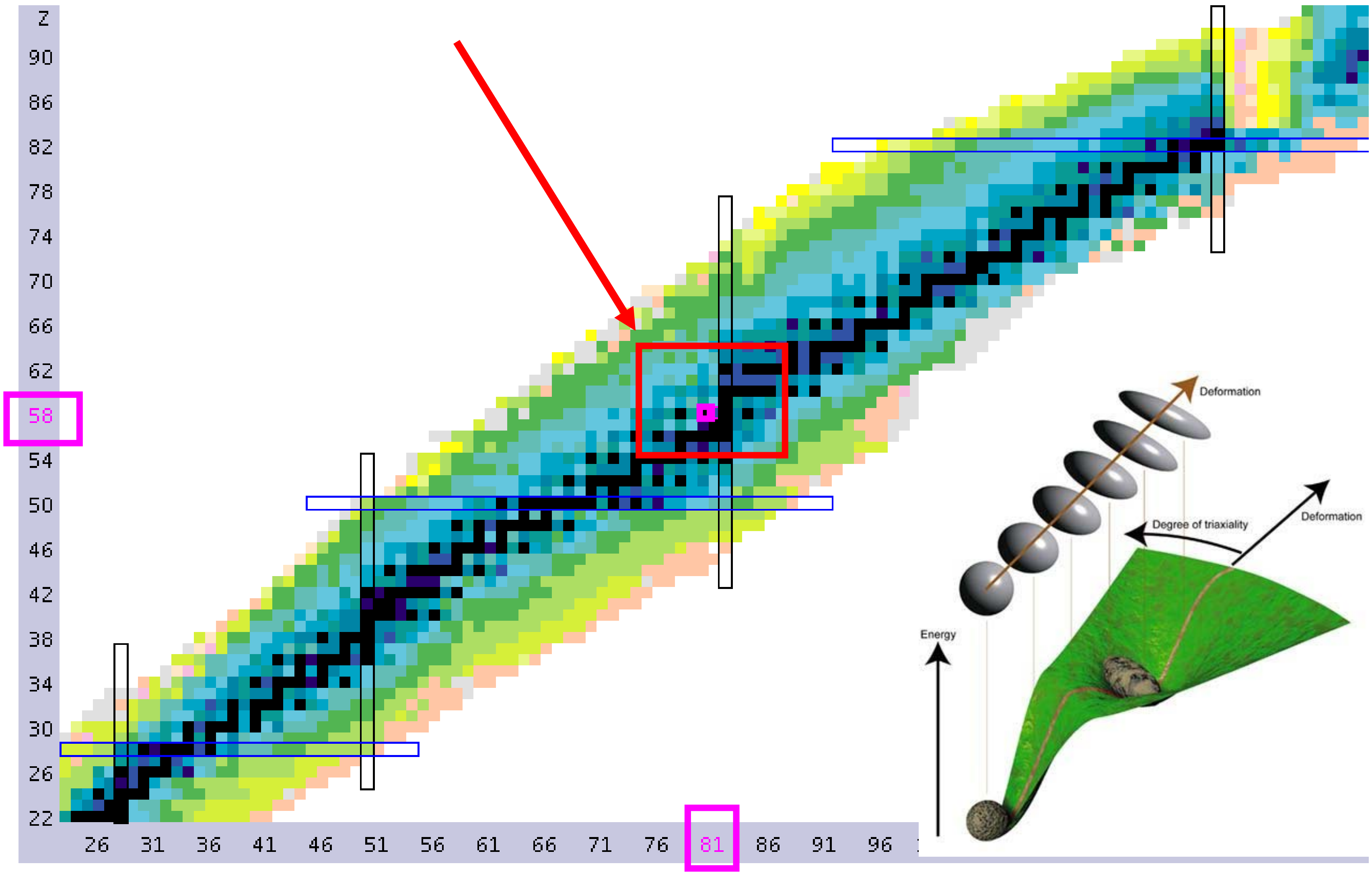

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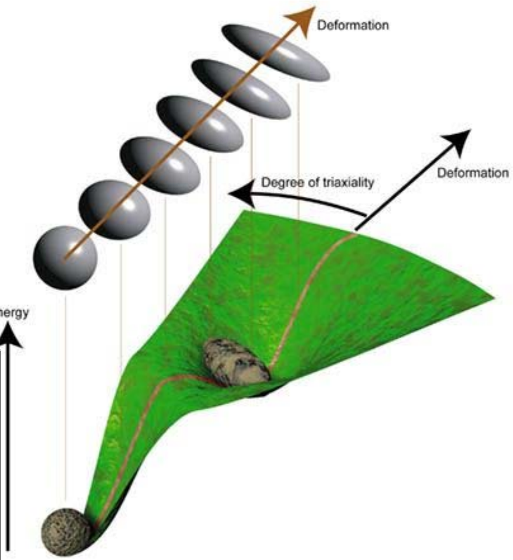
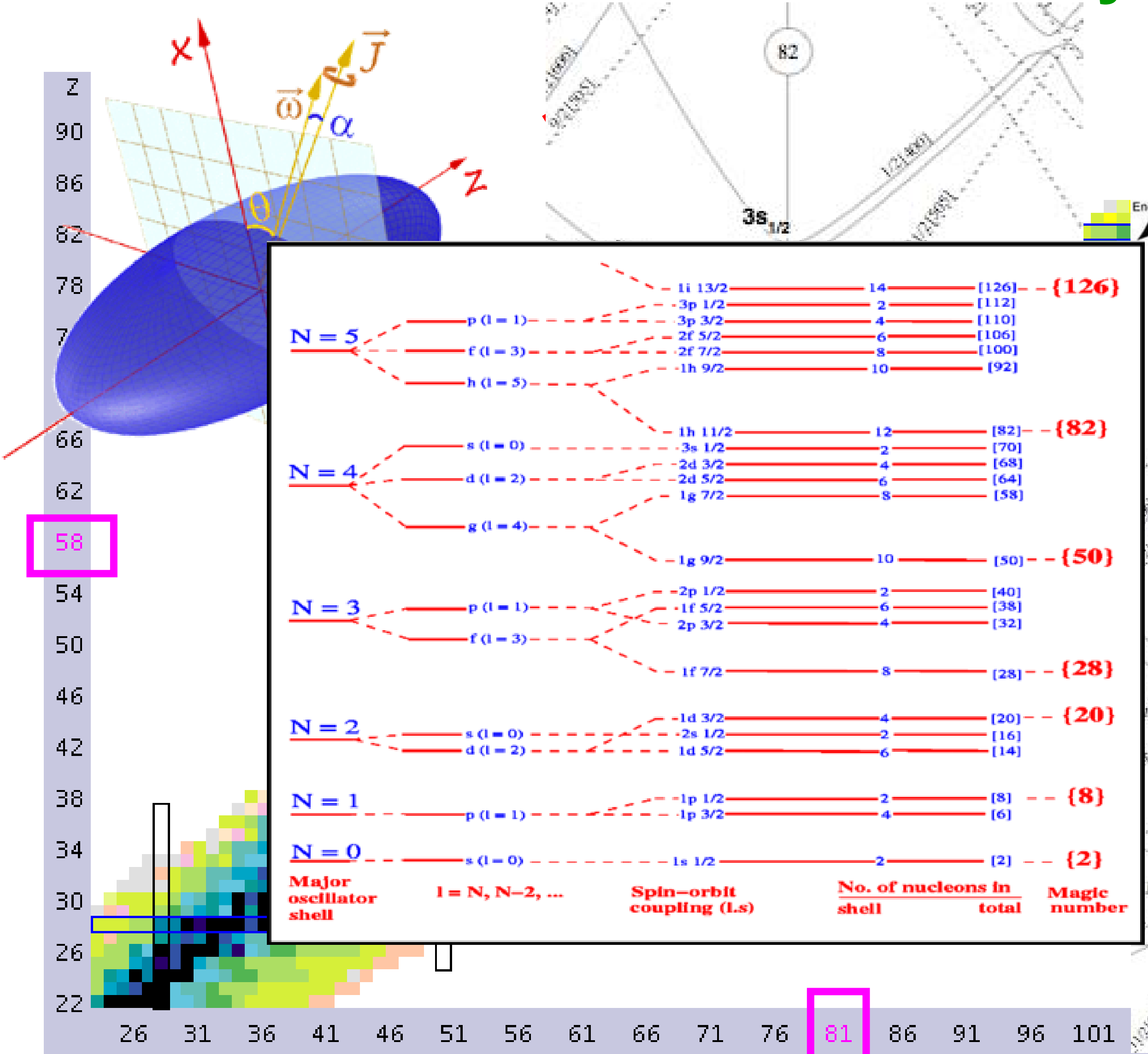
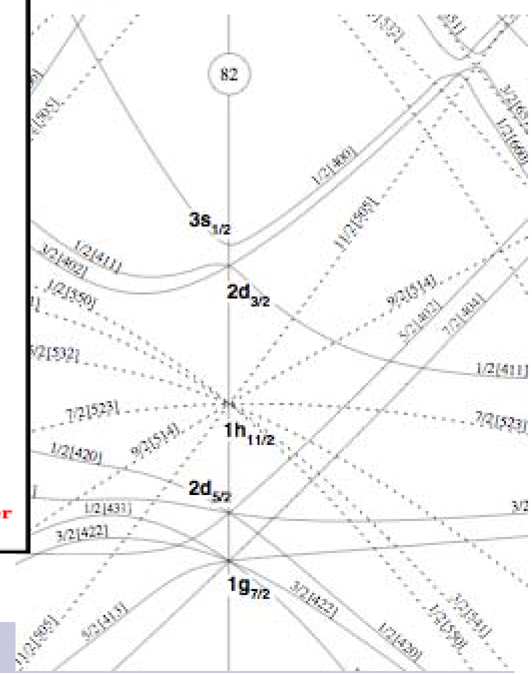


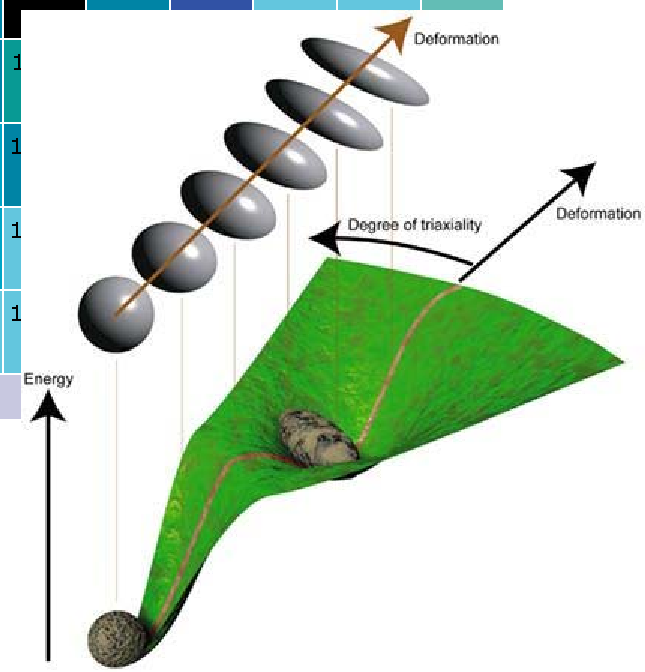




1. Introduction

Around Shell closure N = 82. Why?

Z																	
	135Sm	136Sm	137Sm	138Sm	139Sm	140Sm	141Sm	142Sm	143Sm	144Sm	145Sm	146Sm	147Sm	148Sm	149Sm	150Sm	151Sm
	134Pm	135Pm	136Pm	137Pm	138Pm	139Pm	140Pm	141Pm	142Pm	143Pm	144Pm	145Pm	146Pm	147Pm	148Pm	149Pm	150Pm
60	133Nd	134Nd	135Nd	136Nd	137Nd	138Nd	139Nd	140Nd	141Nd	142Nd	143Nd	144Nd	145Nd	146Nd	147Nd	148Nd	149Nd
	132Pr	133Pr	134Pr	135Pr	136Pr	137Pr	138Pr	139Pr	140Pr	141Pr	142Pr	143Pr	144Pr	145Pr	146Pr	147Pr	148Pr
58	131Ce	132Ce	133Ce	134Ce	135Ce	136Ce	137Ce	138Ce	139Ce	140Ce	141Ce	142Ce	143Ce	144Ce	145Ce	146Ce	147Ce
	130La	131La	132La	133La	134La	135La	136La	137La	138La	139La	140La	1					
56	129Ba	130Ba	131Ba	132Ba	133Ba	134Ba	135Ba	136Ba	137Ba	138Ba	139Ba	1					
	128Cs	129Cs	130Cs	131Cs	132Cs	133Cs	134Cs	135Cs	136Cs	137Cs	138Cs	1					
54	127Xe	128Xe	129Xe	130Xe	131Xe	132Xe	133Xe	134Xe	135Xe	136Xe	137Xe	1					
	73		75		77		79		81		83						



1. Introduction

Around Shell closure N = 82. Why?

Z	137Nd 38.5 M ε: 100.00%	138Nd 5.04 H ε: 100.00%	139Nd 29.7 M ε: 100.00%	140Nd 3.37 D ε: 100.00%	141Nd 2.49 H ε: 100.00%	142Nd STABLE 27.152%	143Nd STABLE 12.174%	144Nd 2.29E+15 Y 23.798% α: 100.00%	145Nd STABLE 8.293%
59	136Pr 13.1 M ε: 100.00%	137Pr 1.28 H ε: 100.00%	138Pr 1.45 M ε: 100.00%	139Pr 4.41 H ε: 100.00%	140Pr 3.39 M ε: 100.00%	141Pr STABLE 100%	142Pr 19.12 H β-: 99.98% ε: 0.02%	143Pr 13.57 D β-: 100.00%	144Pr 17.28 M β-: 100.00%
58	135Ce 17.7 H ε: 100.00%	136Ce >0.7E+14 Y 0.185% 2ε	137Ce 9.0 H ε: 100.00%	138Ce ≥0.9E+14 Y 0.251% 2ε: 100.00%	139Ce 137.641 D ε: 100.00%	140Ce STABLE 88.450%	141Ce 32.508 D β-: 100.00%	142Ce >5E+16 Y 11.114% 2β-	143Ce 33.039 H β-: 100.00%
57	134La 6.45 M ε: 100.00%	135La 19.5 H ε: 100.00%	136La 9.87 M ε: 100.00%	137La 6E+4 Y ε: 100.00%	138La 1.02E+11 Y 0.08881% ε: 65.60% β-: 34.40%	139La STABLE 99.9119%	140La 1.67855 D β-: 100.00%	141La 3.92 H β-: 100.00%	142La 91.1 M β-: 100.00%
56	133Ba 10.551 Y ε: 100.00%	134Ba STABLE 2.417%	135Ba STABLE 6.592%	136Ba STABLE 7.854%	137Ba STABLE 11.232%	138Ba STABLE 71.698%	139Ba 83.06 M β-: 100.00%	140Ba 12.7527 D β-: 100.00%	141Ba 18.27 M β-: 100.00%
	77	78	79	80	81	82	83	84	N