Two-phonon octupole collectivity in the doubly-magic nucleus ^{146}Gd

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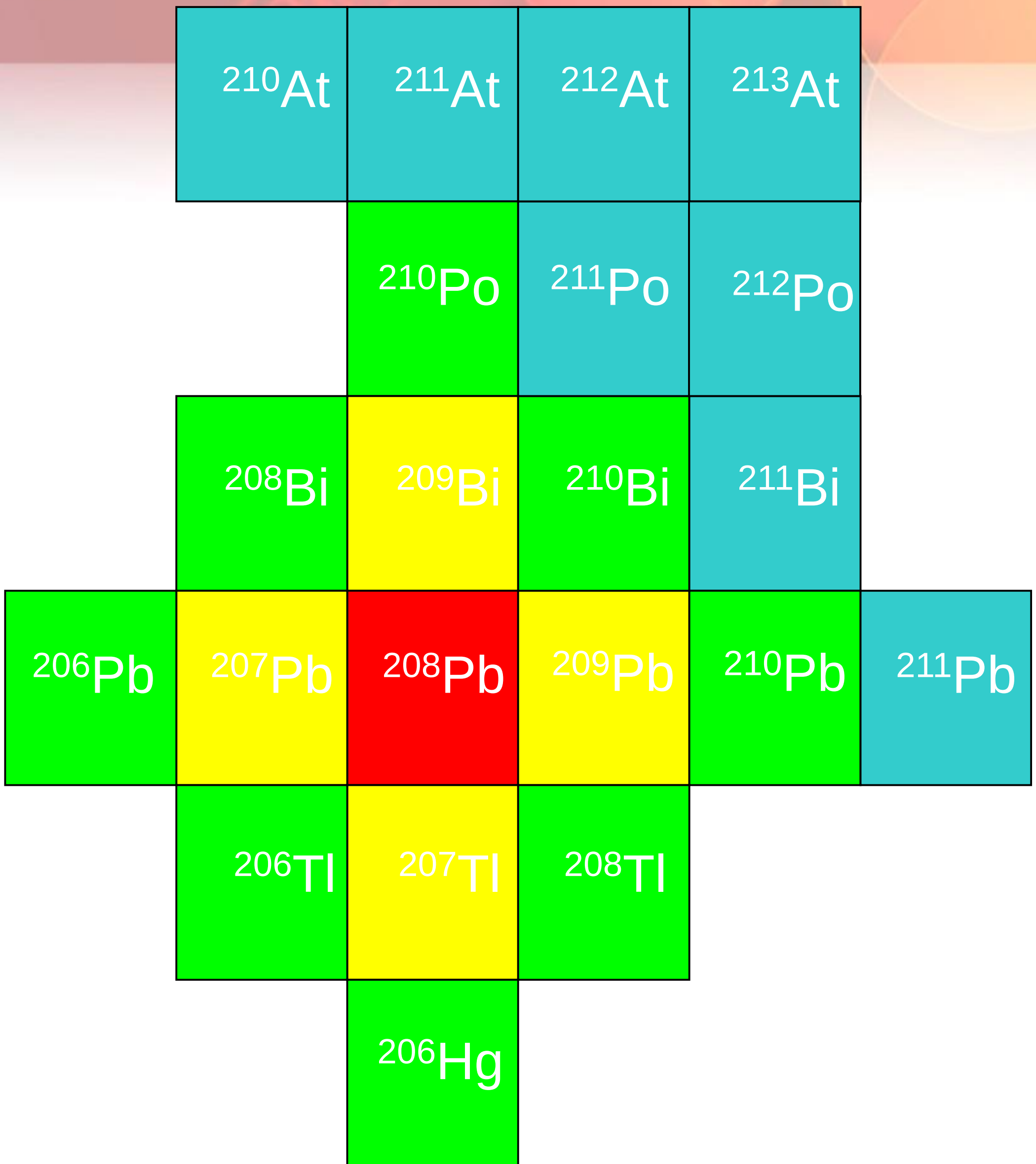
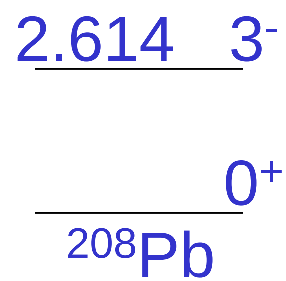
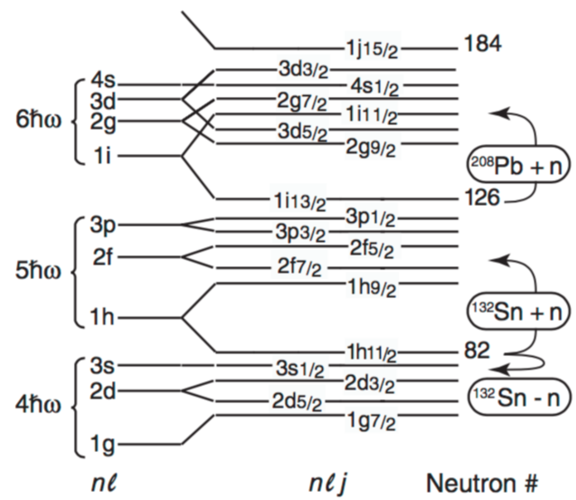
PRL **112,** 172701 (2014) PHYSICAL REVIEW LETTERS week ending 2 MAY 2014

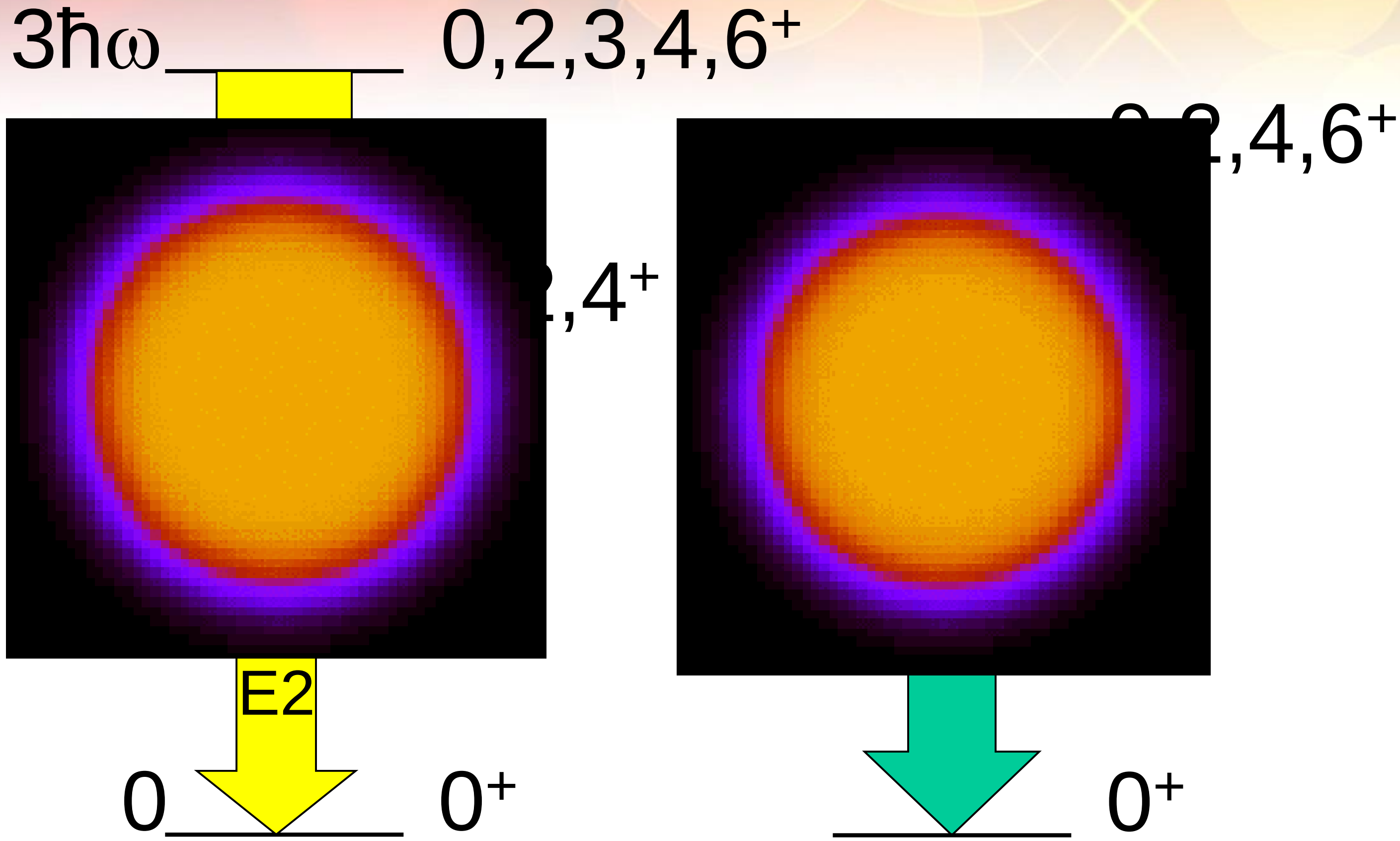
Double-Magic Nature of ^{132}Sn and ^{208}Pb through Lifetime and Cross-Section Measurements



^{208}Pb - central to our understanding of the nuclear shell model







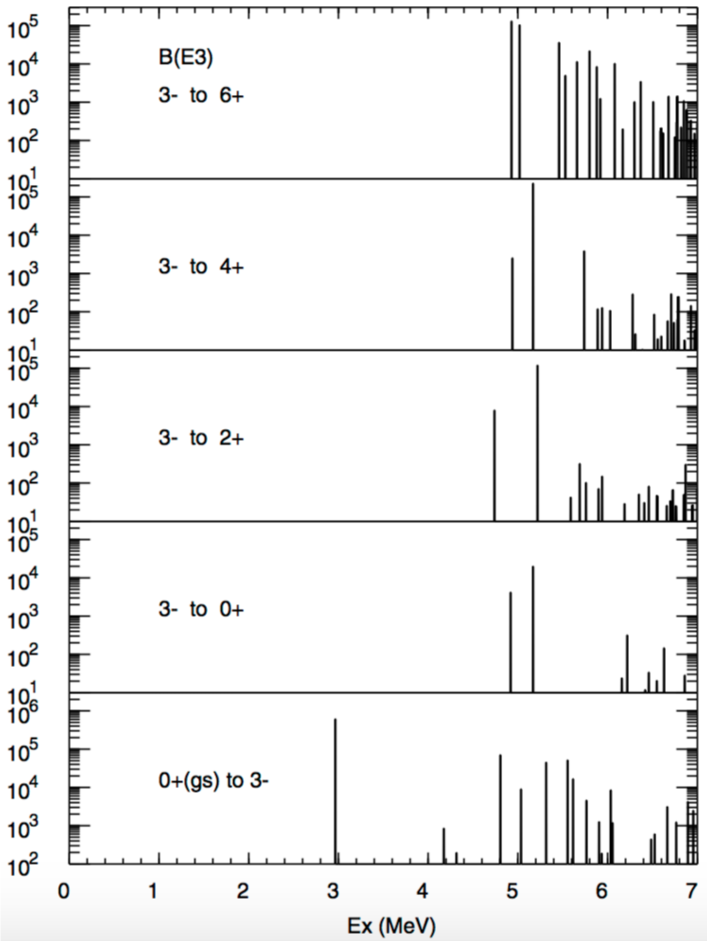
Quadrupole Vibration

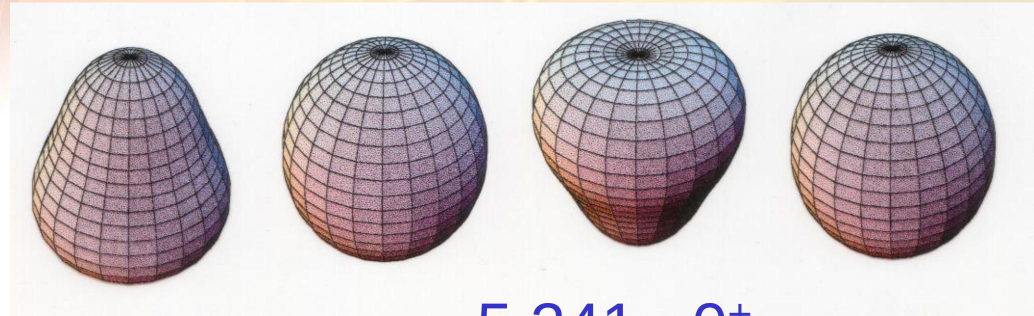
Octupole Vibration

VOLUME 85, NUMBER 25 PHYSICAL REVIEW LETTERS 18 DECEMBER 2000

Double-Octupole States in ^{208}Pb

B. Alex Brown





Fragmented
6^+ state

B(E3) ≈ 34 W.u.

5.241 0^+

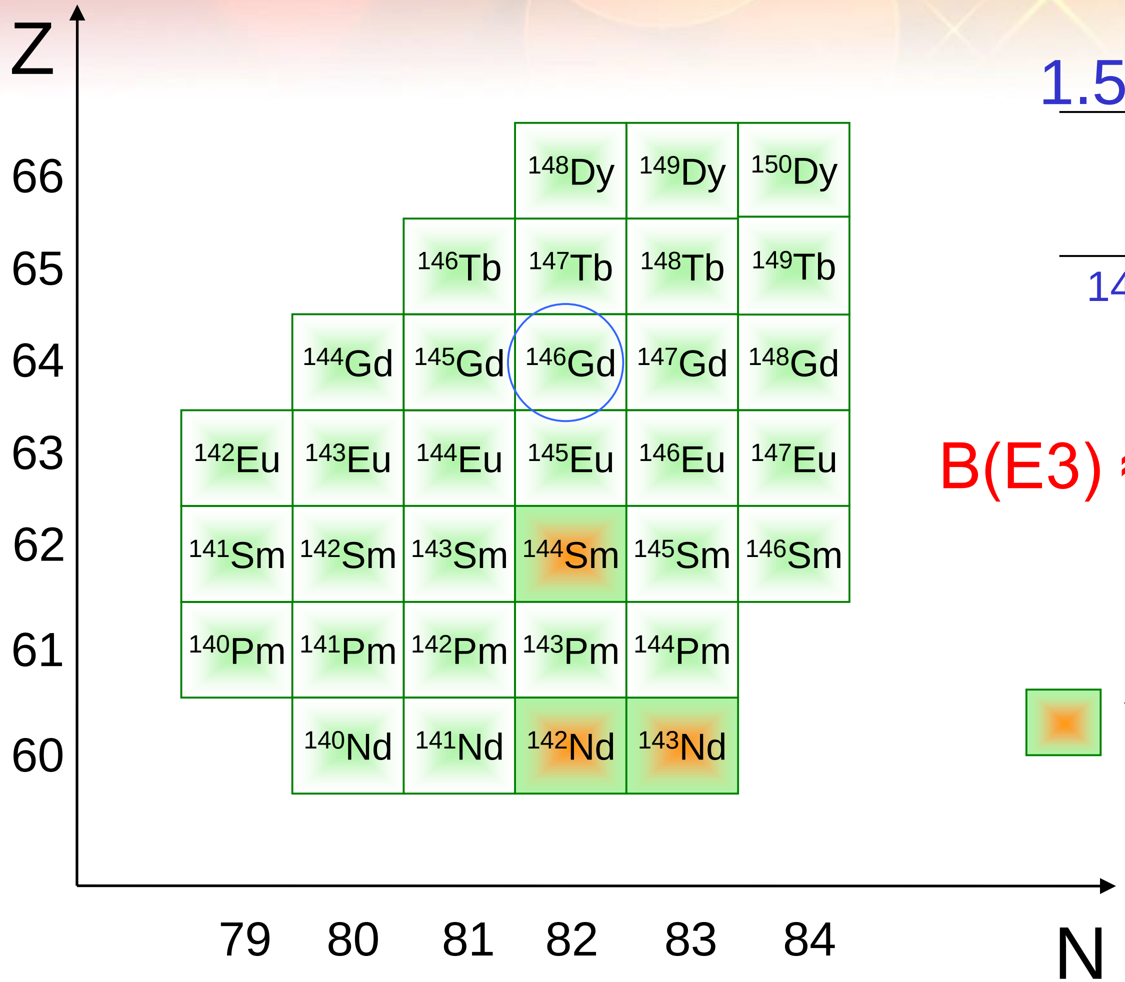
2.614 3^-

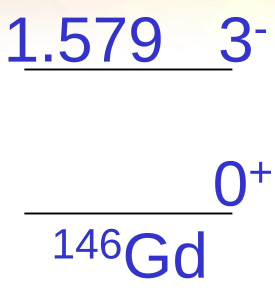
0^+

^{208}Pb

$$|3^-\rangle = 0.36|\pi(h_{9/2}d_{3/2}^{-1})\rangle + 0.27|\pi(f_{7/2}s_{1/2}^{-1})\rangle + 0.27|\pi(i_{13/2}h_{11/2}^{-1})\rangle + 0.44|\nu(g_{9/2}p_{3/2}^{-1})\rangle + 0.37|\nu(i_{11/2}f_{5/2}^{-1})\rangle + 0.3|\nu(j_{15/2}i_{13/2}^{-1})\rangle + \ldots$$

The Doubly-magic nucleus ^{146}Gd

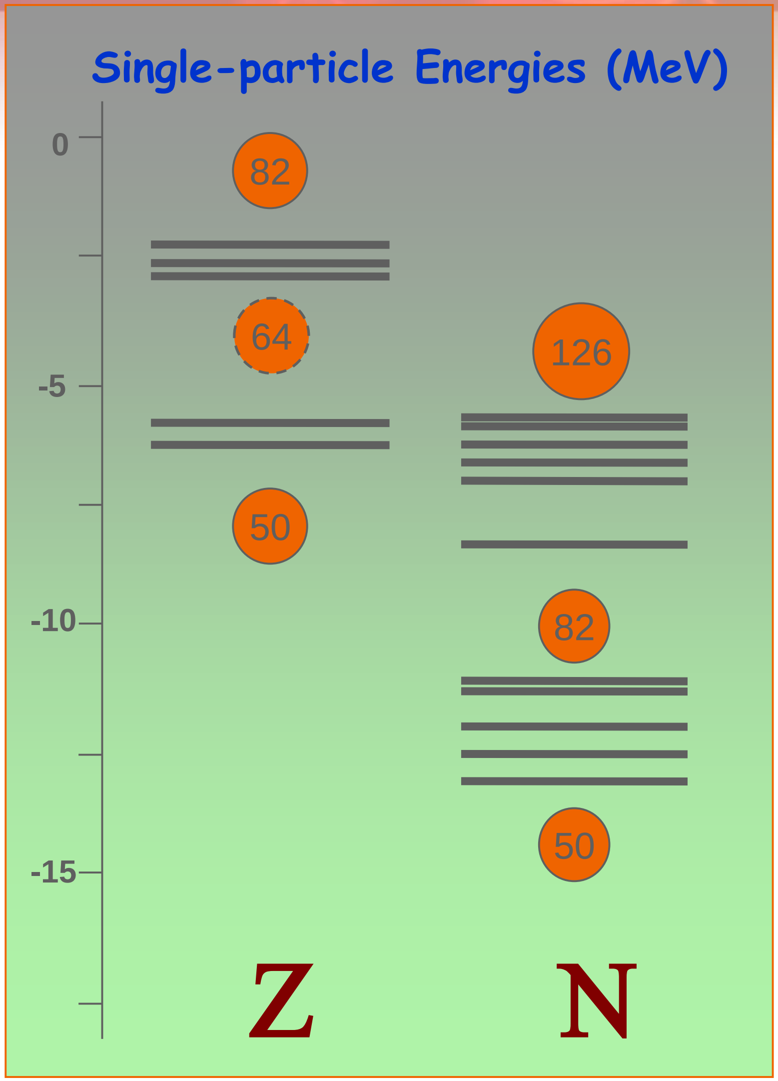




B(E3) ≈ 37(4) W.u.

stable nuclei

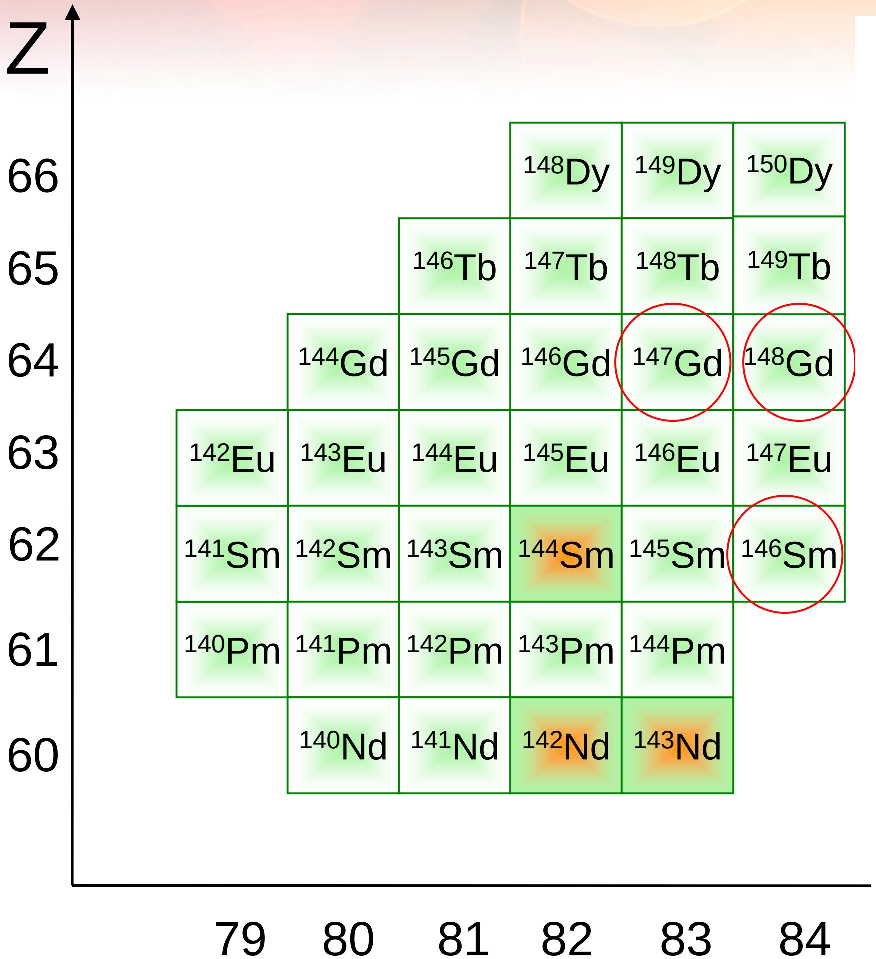
The Doubly-magic nucleus ^{146}Gd

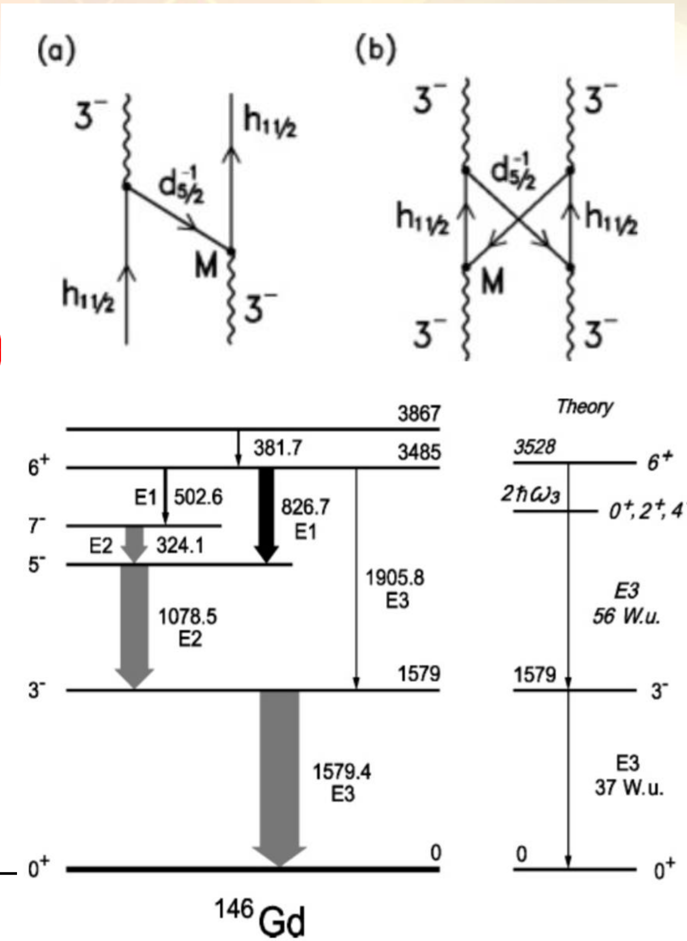


- ^{146}Gd has the features of a doubly closed shell nucleus.
- ^{146}Gd is the only doubly even nucleus besides ^{208}Pb with a 3^- first excited state (lowest in energy).
- It is accesible by low momentum transfer fusion-evaporation reactions.
- Expectation to observe the $3^- \otimes 3^-$ double octupole.

S.W.Yates et al.. Z. Phys. A324 (1986) 417

two-octupole phonon states in ^{146}Gd



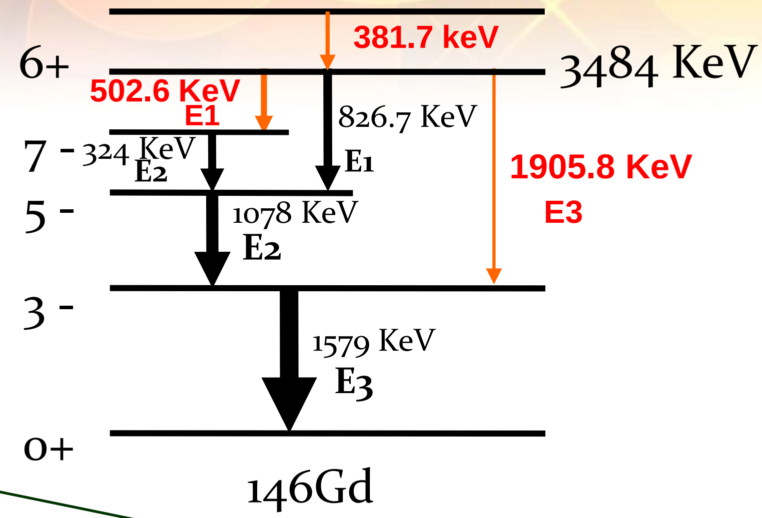


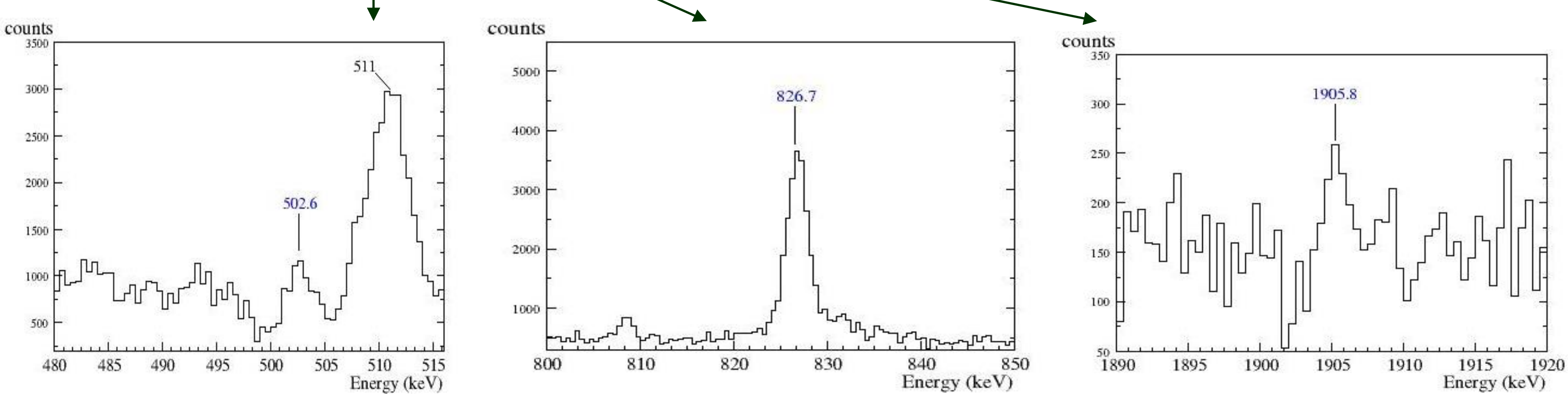
N

The Doubly-magic nucleus ^{146}Gd

Caballero L. *et al.*, (2010).
***Phys. Rev. C* 81, 031301**

381.7 keV gate



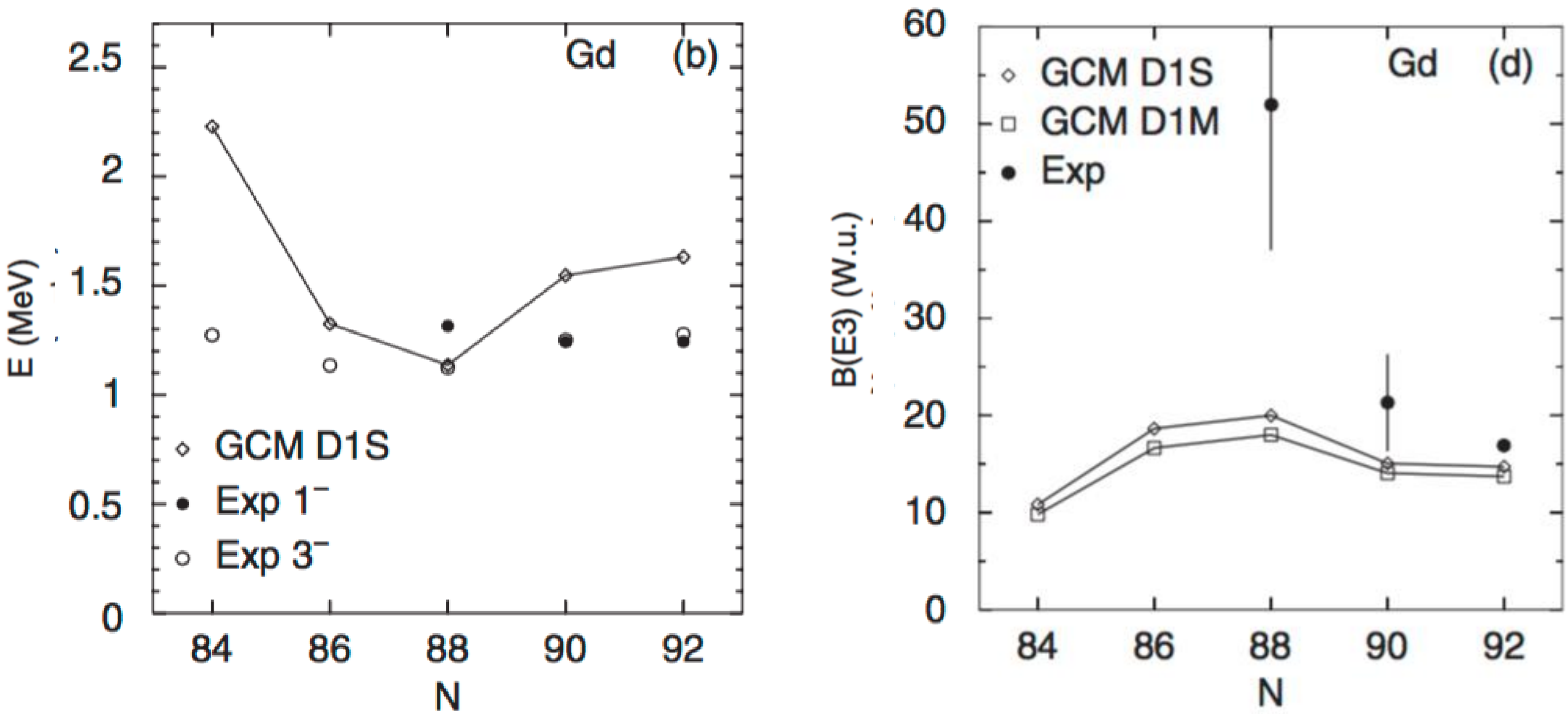


PHYSICAL REVIEW C **86**, 034336 (2012)

Microscopic description of quadrupole-octupole coupling in Sm and Gd isotopes with the Gogny energy density functional

R. Rodríguez-Guzmán,[1,2] L. M. Robledo,[3] and P. Sarriguren[4]

Generator Coordinate Method with an axial octupole moment as generating coordinate



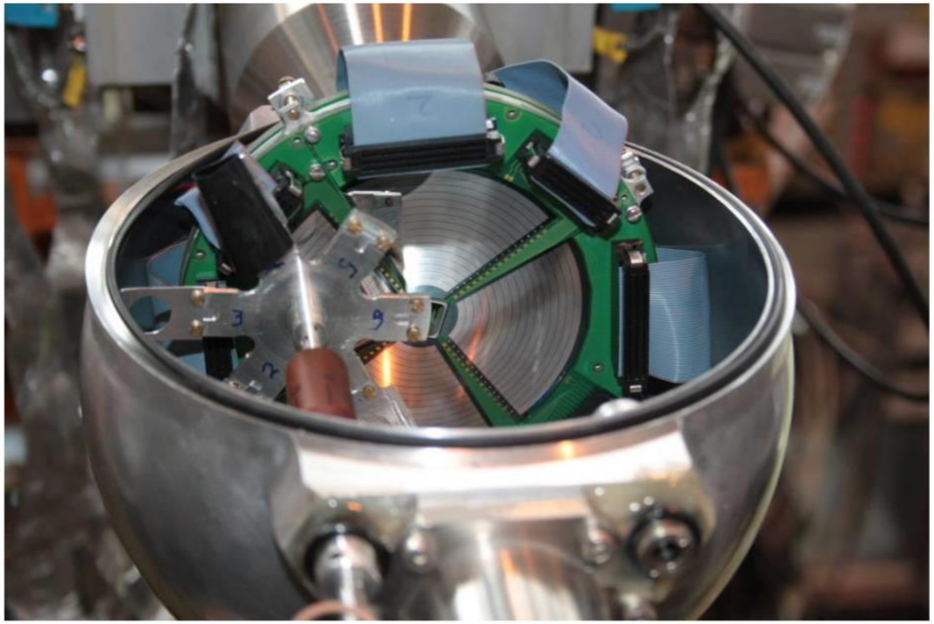
For ^{146}Gd E_x^{3-} ≈ 3 MeV E_x^{6+}≈6 MeV B(E3:3^-→ 0^+)≈24 W.u. B(E3:6^+→3^-)≈54 W.u.

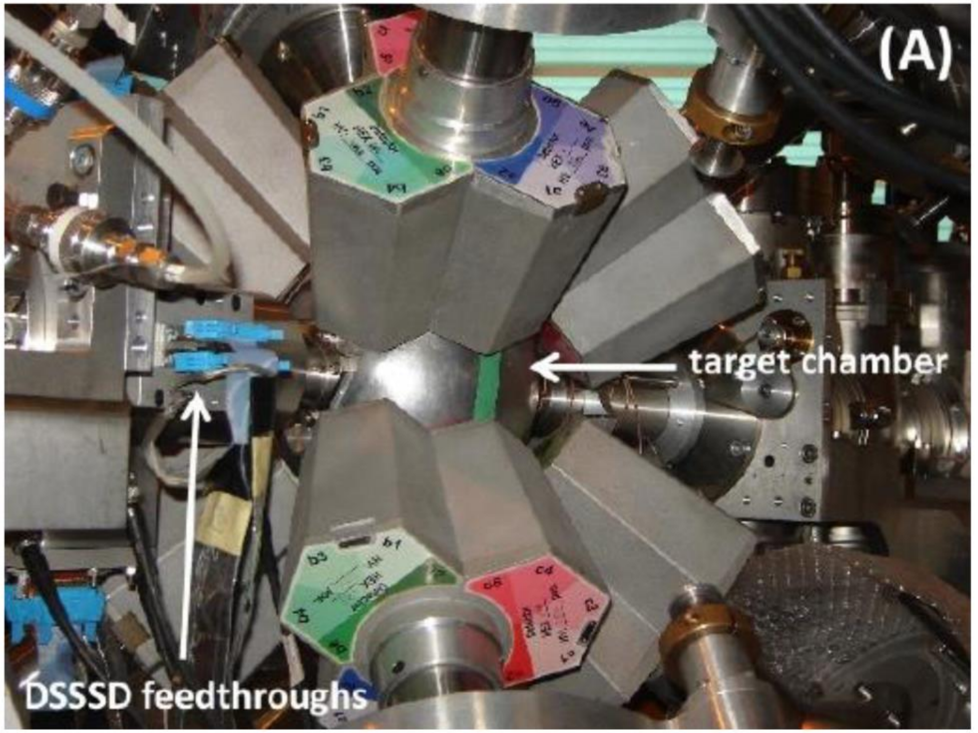
Coulomb Excitation of ^{146}Gd

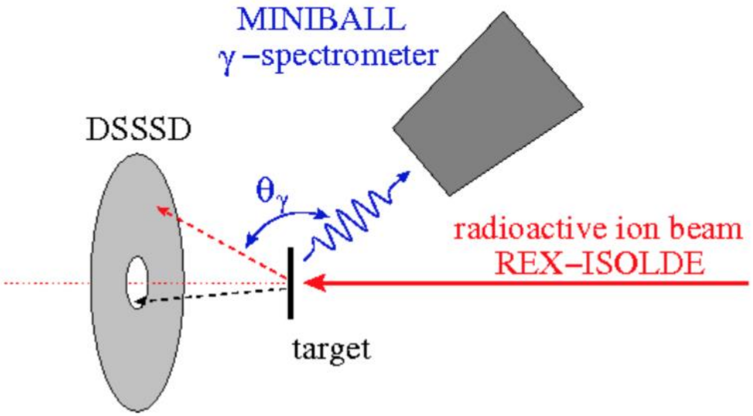
MINIBALL
Coulomb excitation setup

segmented Si detector for particle detection (DSSSD)

- 16 rings (front side)
- 96 strips (back side)
- angle coverage: θ_{lab} = 16-55°
- ΔE-E measurement possible (pad)







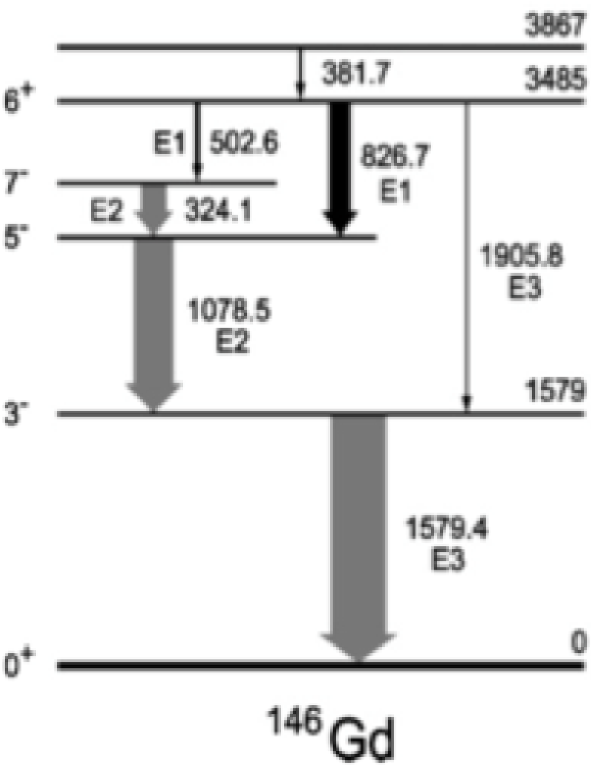
N. Warr, et al., Eur. Phys. J. A (2013) 49: 40

GOSIA rate estimate

Projectile and recoiling nuclei between 16 and 53 degree in the lab
146Gd E=800 MeV on 1 mg/cm2 Pb target

$I(^{146}Gd) = 10^6$ pps

Transition matrix elements for $3^- \rightarrow 0^+$, ^{7}-$\rightarrow 5^-$
$6^+ \rightarrow 5^-$, $6^+ \rightarrow 7^-$ from [P. Daly et al.Z. Phys. A 298 173 (1984)]
$6^+ \rightarrow 3^-$ [L. Caballero et al. PRC81,031301R (2010)] $5^- \rightarrow 3^-$ SM estimate

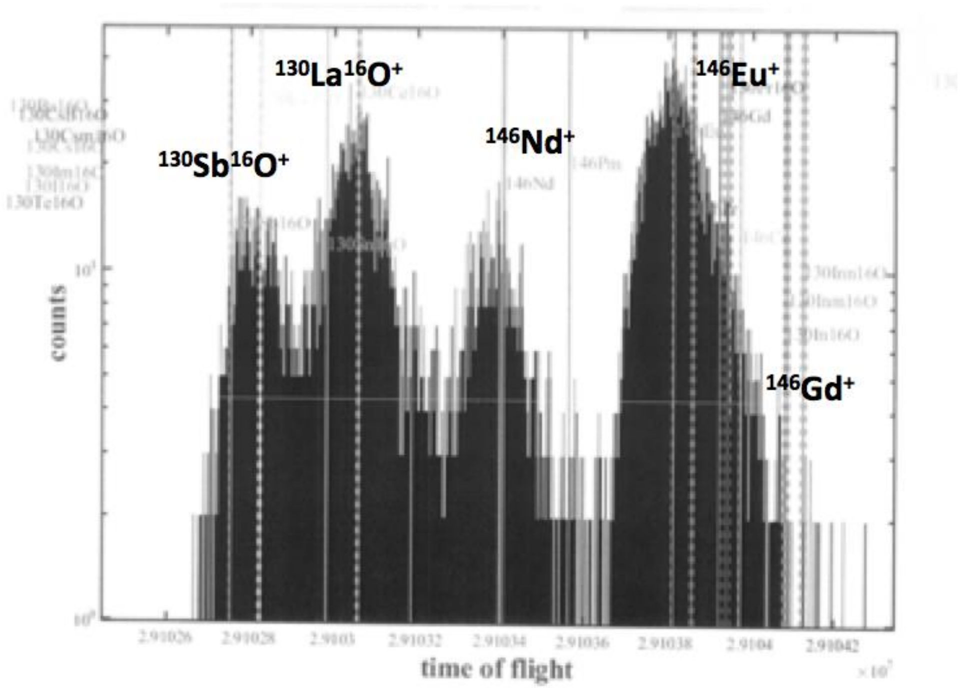


I_i	I_f	Multipolarity	$B(E\lambda; I_i \rightarrow I_f)$ [Wu]	Eγ [keV]	Counts/day
3^-	0^+	E3	37	1579	6100
5^-	3^-	E2	0.46	1079	160
7^-	5^-	E2	0.46	324	45
6^+	3^-	E3	56	1905	4
6^+	5^-	E1	$3 * 10^{-5}$	827	100
6^+	7^-	E1	$4*10^{-5}$	503	40
2^+	0^+	E2	0.4	1972	430

Beam Composition (^{146}Gd) using MR-TOF

Ta foil target # 565 Ion source temperature 2150^0

A=146
Beam purity about 3%

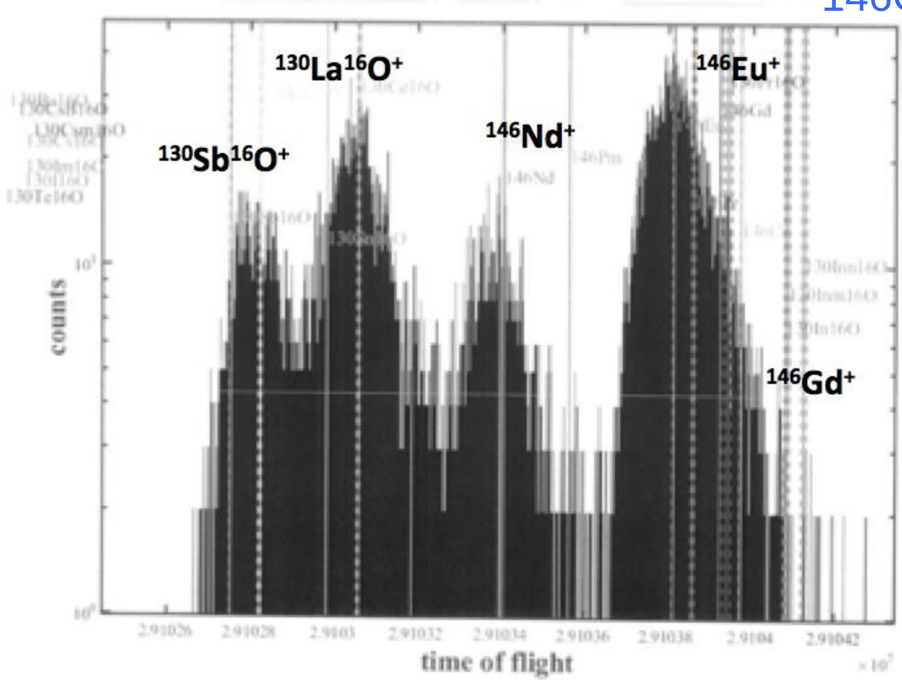


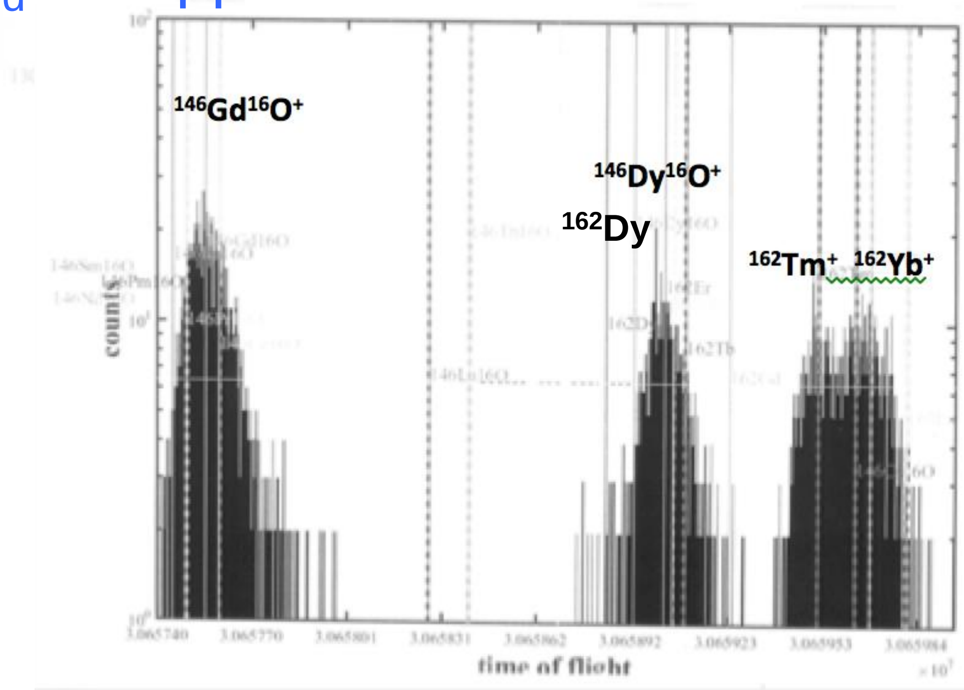
Beam Composition (^{146}Gd) using MR-TOF

Ta foil target # 565 Ion source temperature 2150^0

A=162
Beam purity about 45%

I_{146Gd}=10^8 pps





High beam purity expected breaking the molecule in Rex-EBIS

Beamtime request

Requested shifts

- we expect 4 counts per day for the 1905.8 keV $6^+ \rightarrow 3^-$ and 100 counts per day for the 826.7 keV $6^+ \rightarrow 5^-$ transitions with a full statistics of 24 and 600 counts collected in 6 days of beam time (18 shifts). 6^+ populated only via E3 and extracted through the 826.7 E1 strength.
- The expected statistics should be sufficient to search for other members of the double-phonon multiplet.
- Independent normalization of the B(E3, 3- -> 0+) achieved through comparison with the target excitation (^{94}Mo) which has a well known B(E2) strength and no overlapping gamma transitions. We expetct 500 counts in two days (6 shifts)

- ^{146}Gd beam 24 shifts (18 shifts on ^{208}Pb target and 6 shifts on ^{94}Mo)

Thanks for attention

Collaboration

G. de Angelis, K. Hadynska-Klek, M. Zielinska, B. Rubio, M. J. G. Borge, L. Razvan, K. Johnston, S. Lunardi, J.N. Orce, A. Algora, L. Caballero, A. Gadea, J.L. Tain, S.A.E. Orrigo, A. Morales, S. W. Yates, F. Gramegna, A. Goasduff, G. Jaworski, D.R. Napoli, G. Prete, M. Siciliano, J. Valiente Dobon, D. Bazzacco, F. Recchia, A. Boso, P.R. John, S.M. Lenzi, R. Menegazzo, D. Mengoni, D. Testov, B. Melon, A. Nannini, C. Fahlander, R. Orlandi, P. Reiter, D. Rosiak, M. Seidlitz, N. Warr, T. Kroell, T.D. Goodacre, B. Marsh, O. Sorlin, W. Gelletly, M. Rocchini, E. Sahin, E. Ganioglu, R. Julin, R. Broda, S. Leoni, G. Bocchi, G. Benzoni, D. Santonocito, U. Koester

Thanks for attention