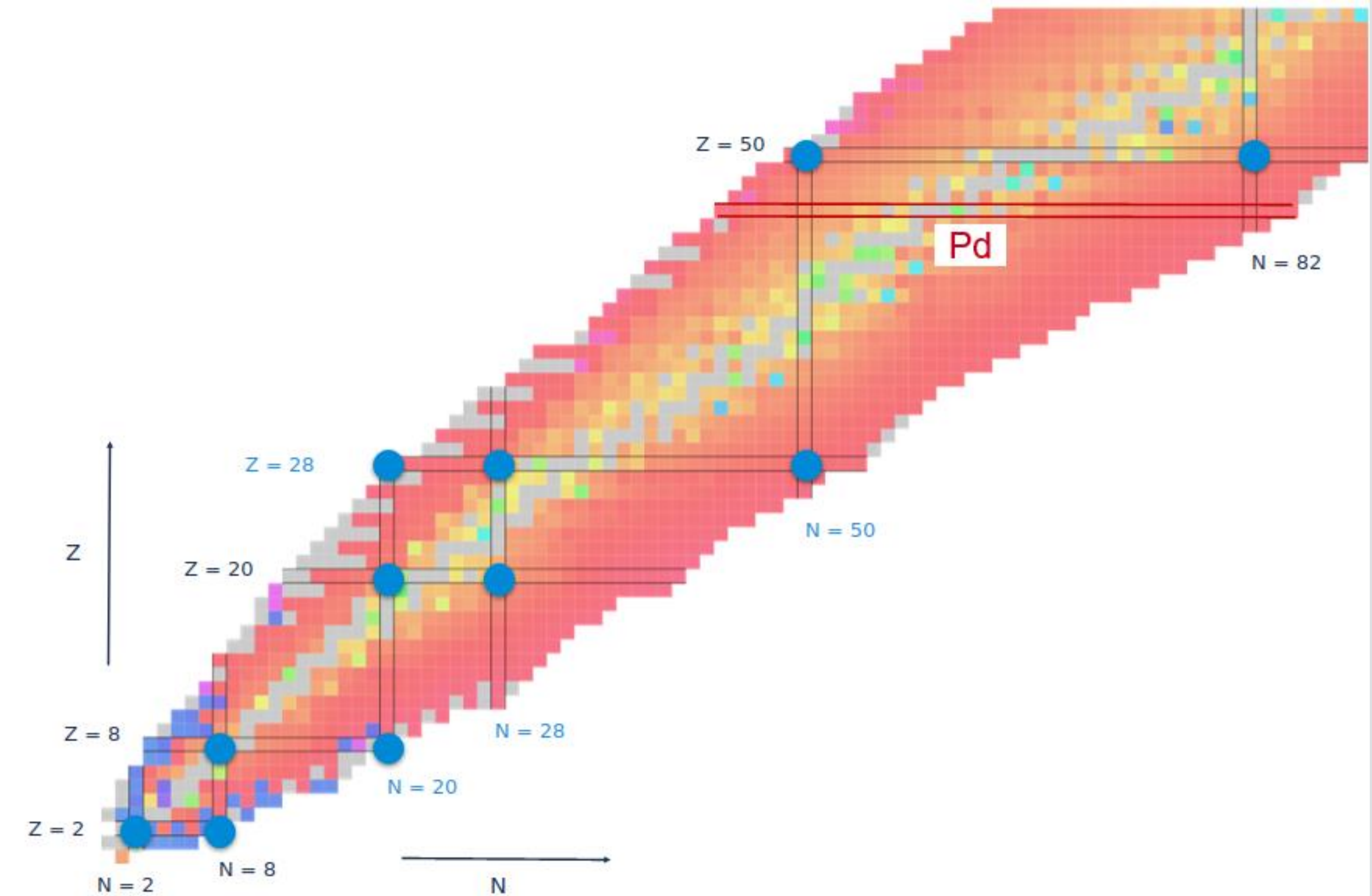
Naomi Marchini
INFN Florence section

Using Coulomb excitation to study the low-lying structure of ^{104}Pd

AGATA+SPIDER Setup

Spokespersons: Naomi Marchini, Adriana Nannini, Desislava Kalaydjieva, Iwona Zofia Pietka

Physics around Z=50



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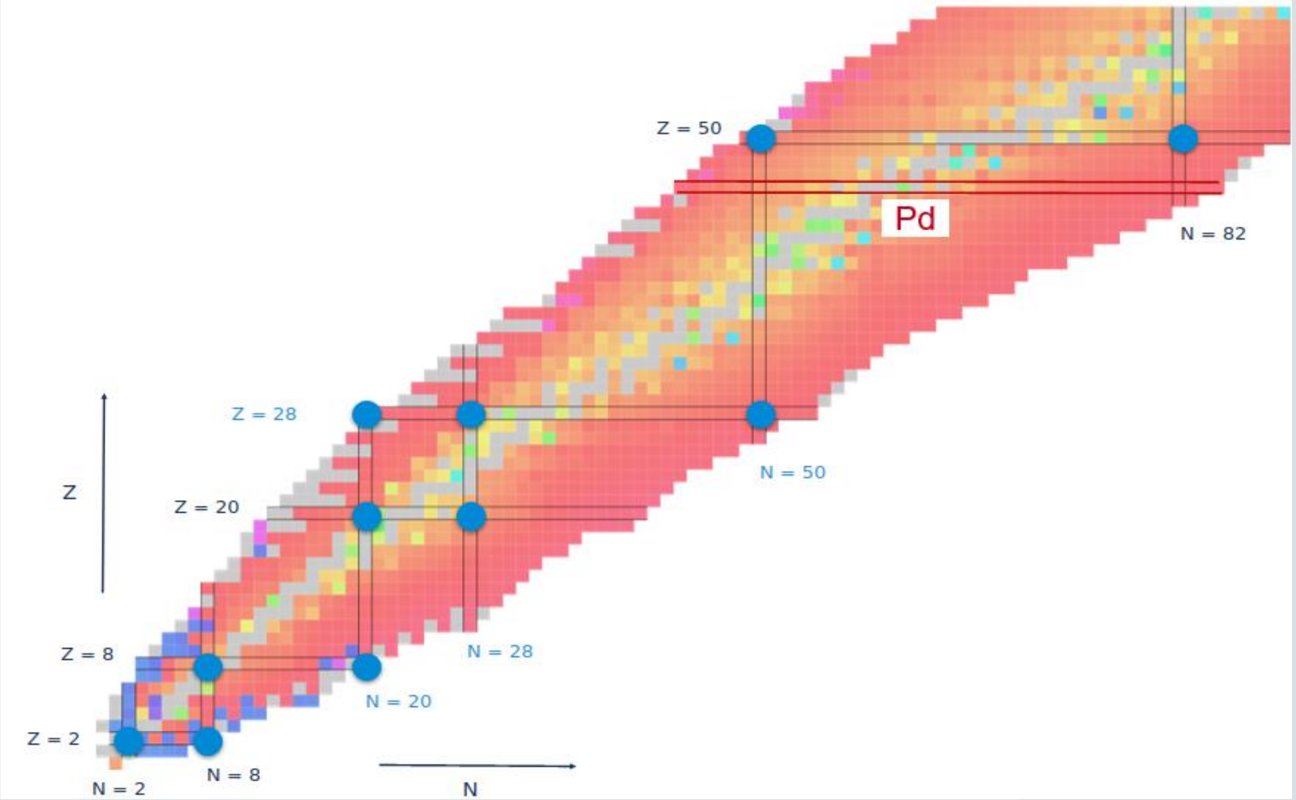

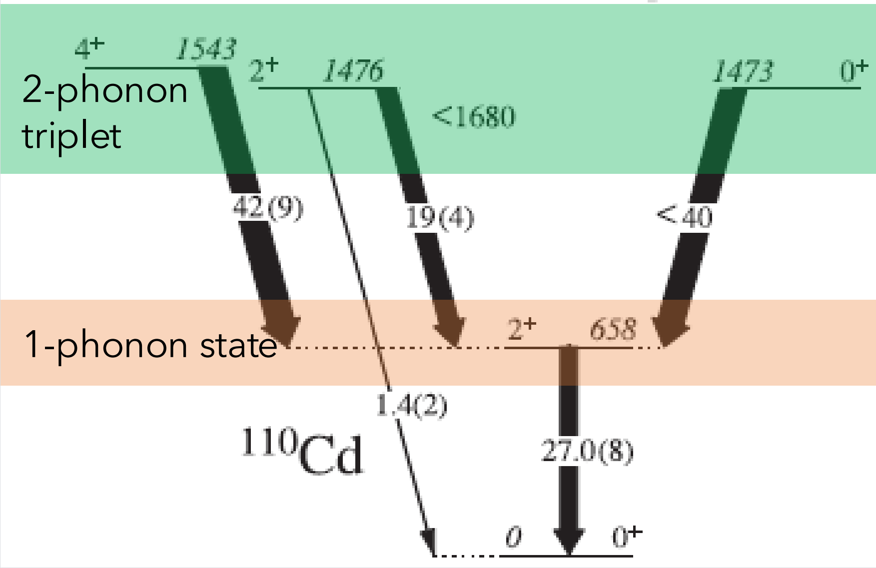

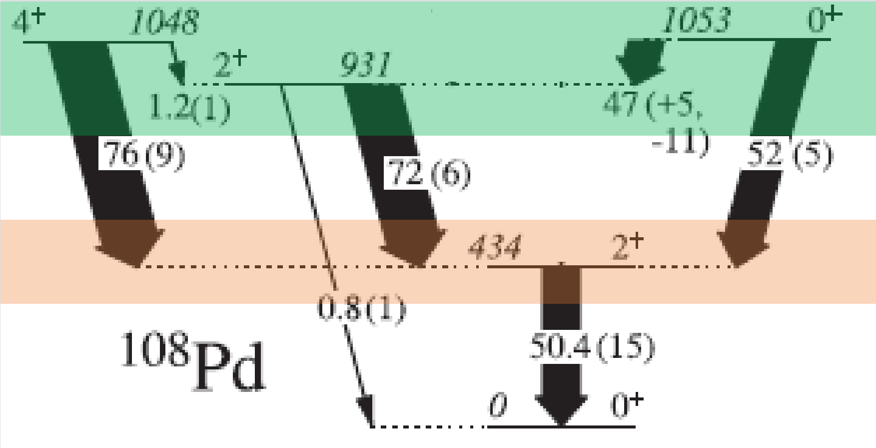

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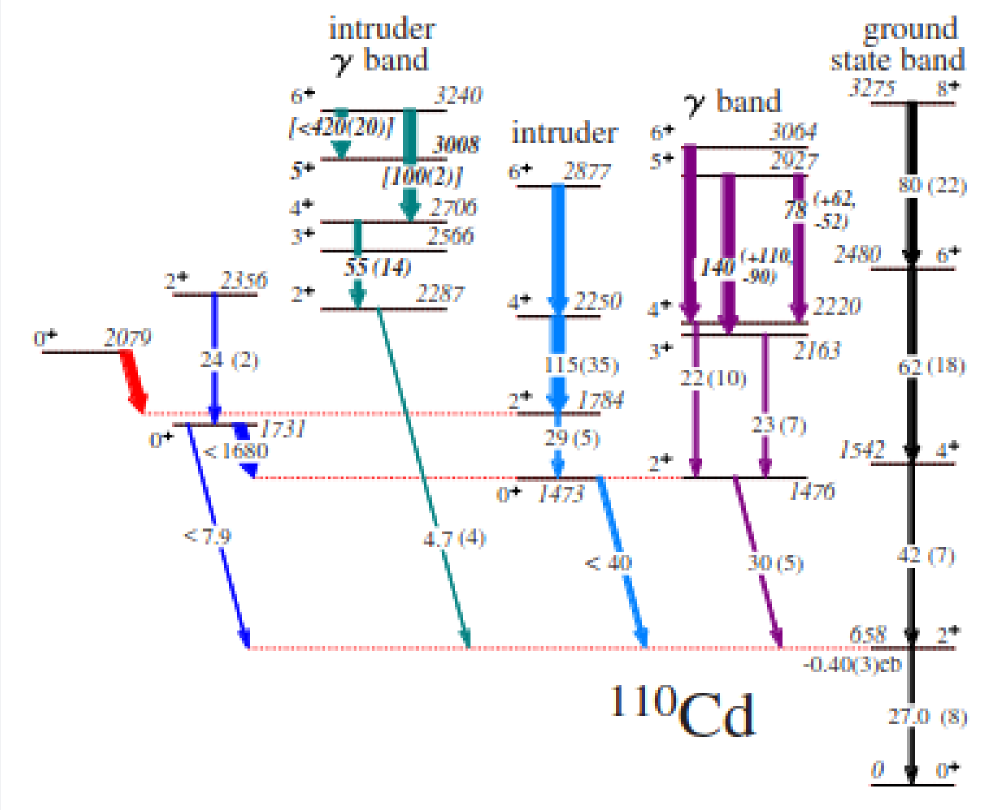

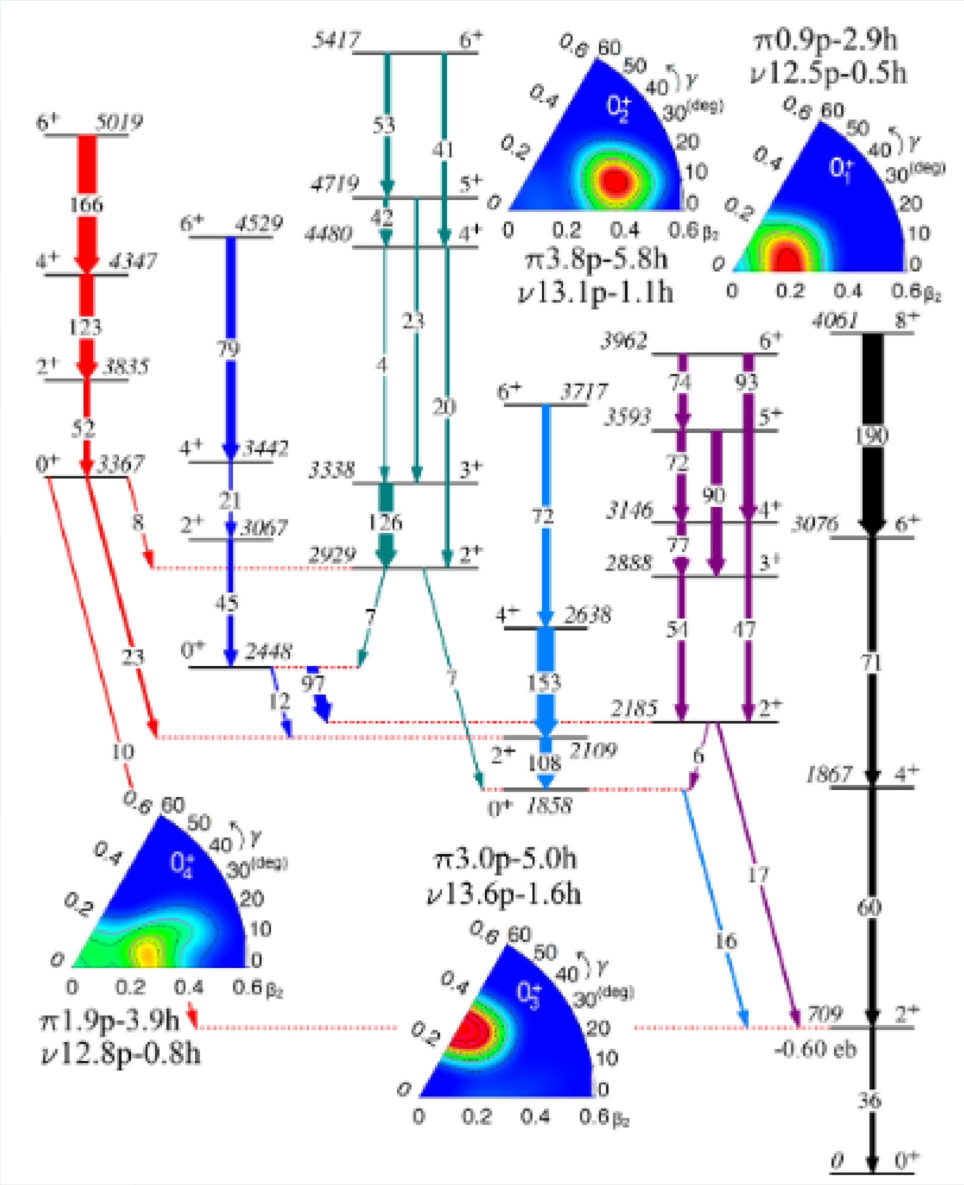

Suggested presence of multiple shape coexistence

P.E. Garrett et al., Phys. Rev. Lett. 123 (2019) 142502

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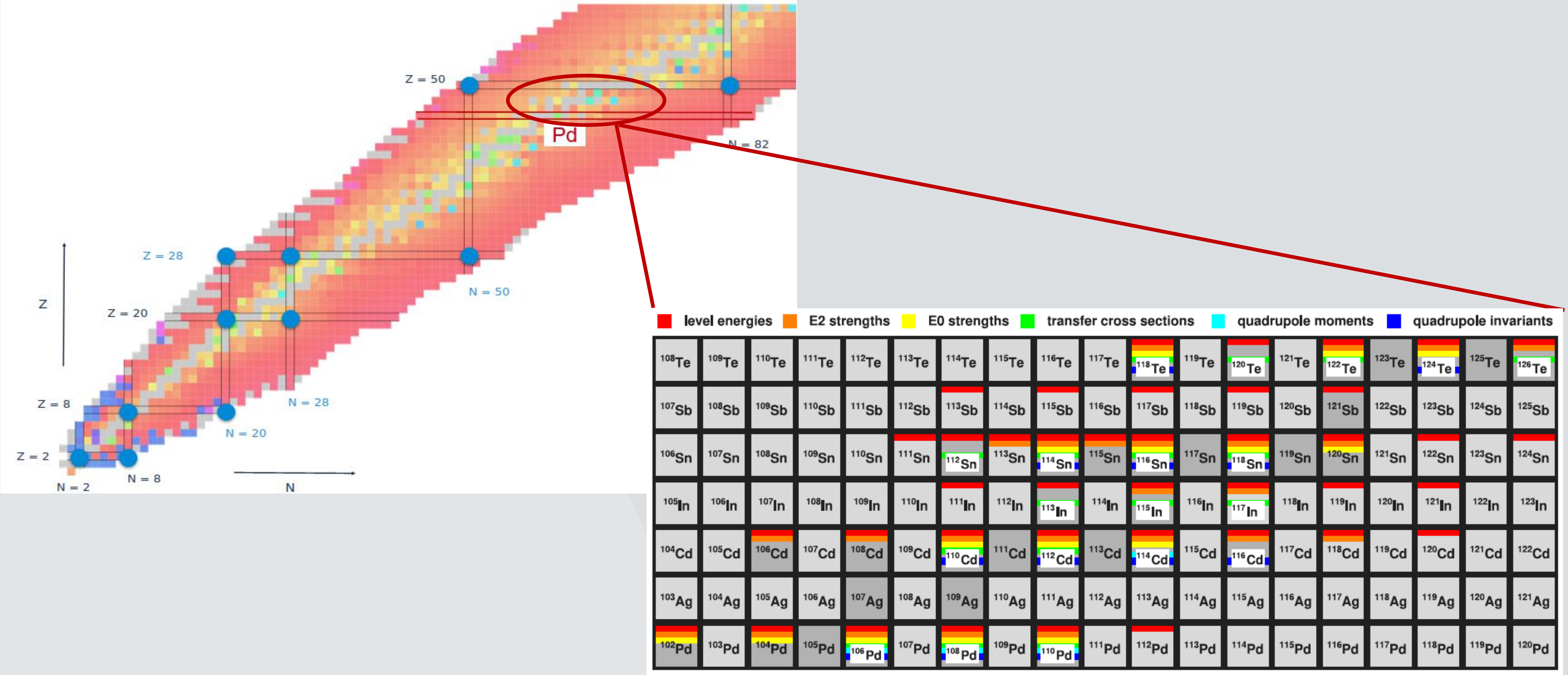

P.E. Garrett, M. Zielińska and E. Clément Progress in Particle and Nuclear Physics 124 (2022) 103931

The ^{104}Pd isotope

- Experimental data on the electromagnetic structure are surprisingly scarce
- Lifetimes have been studied only for the members of the ground state band
- Coulomb-excitation measurements performed with light beams leading to the population of a limited number of low-lying levels

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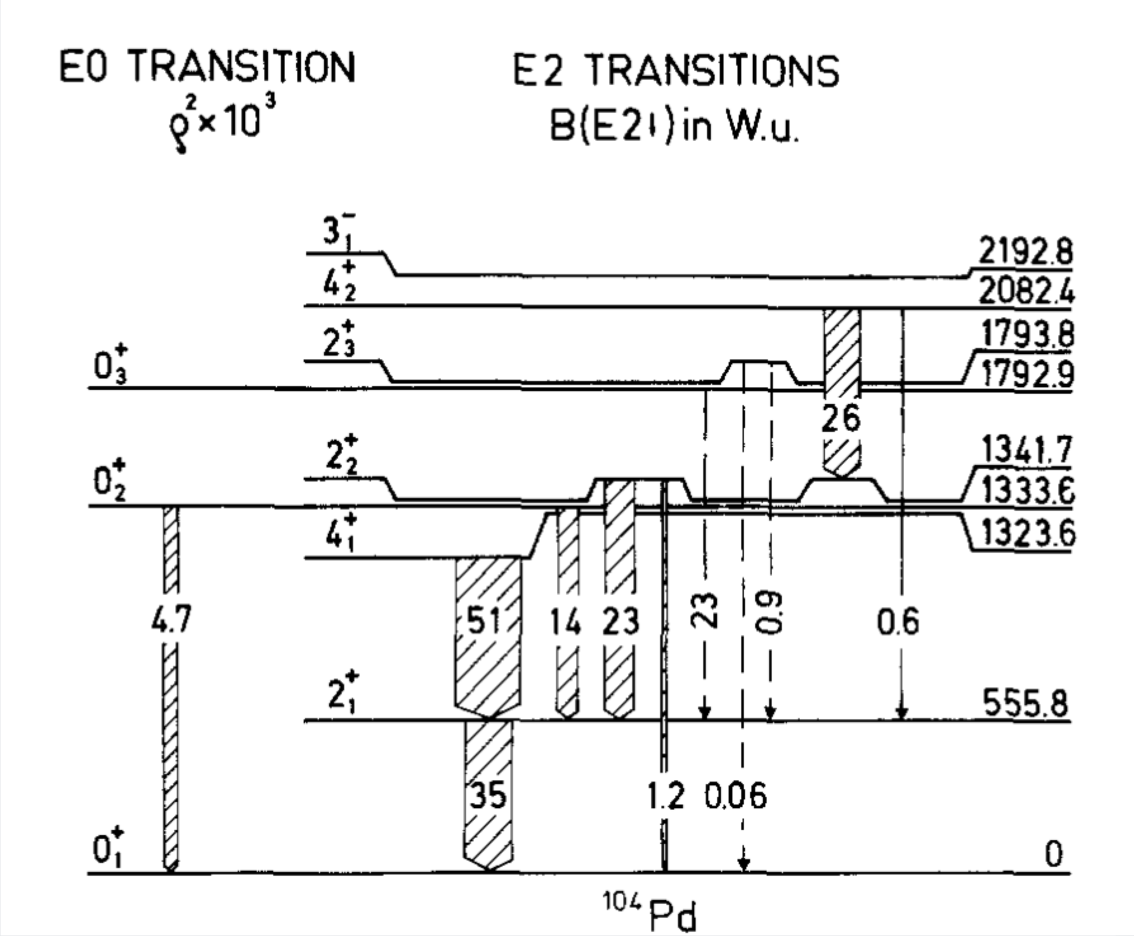

M. Luontama et al., Z. Phys. A 324, 317 (1986)

Coulomb excitation using ^{16}O beam and coincidence between Ge(Li) and NaI(Tl) detectors

✓ The reduced transition probabilities for the decay of the 2_1^+ , 2_2^+ , 0_2^+ , 4_1^+ , 4_2^+ and 3_1^- states deduced

- Only upper limits of the reduced transition probabilities from the 2_3^+ and 0_3^+ states
- No observation of the 0_4^+ state

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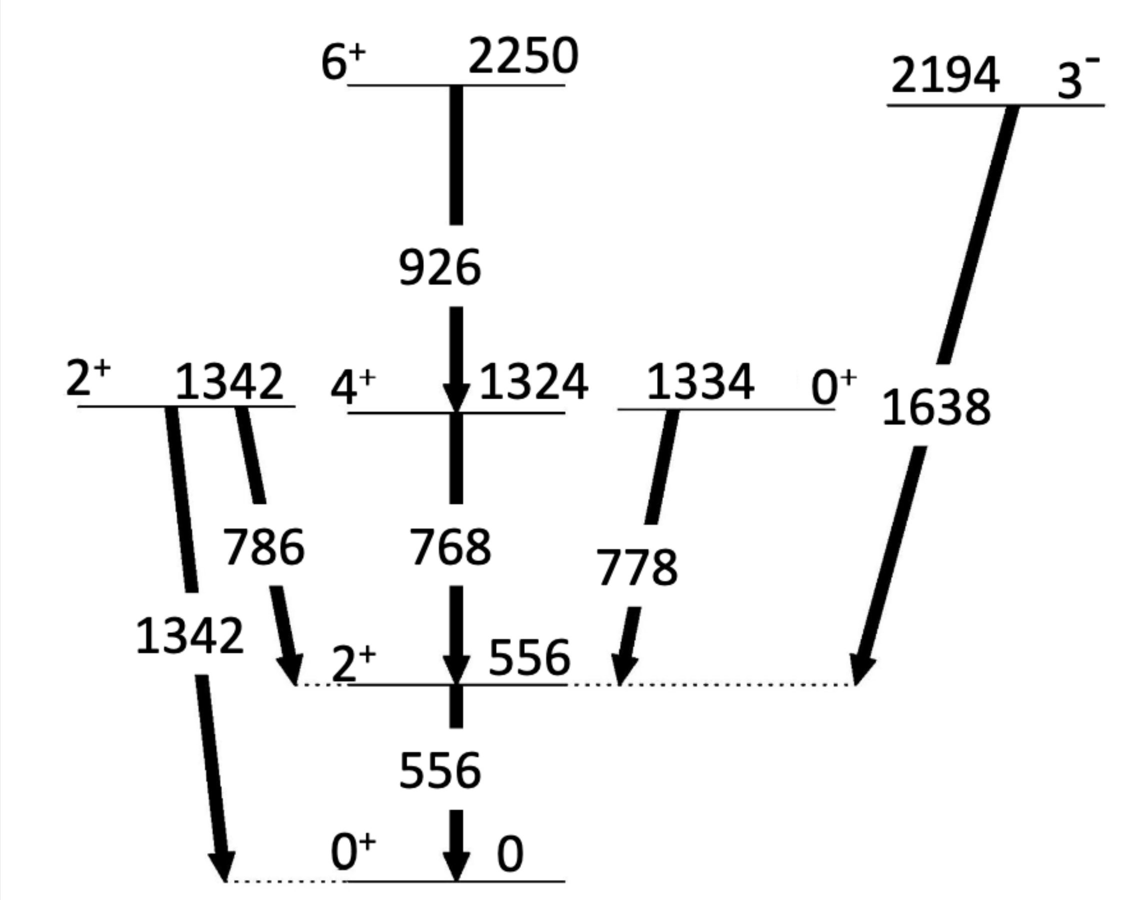

S. Dutt, P. Napiorkowski, et al., Acta Physica Polonica B 47, 917 (2016)

Coulomb excitation using ^{32}S beam and coincidence between EAGLE spectrometer and PIN-diode array

✓ The reduced transition probabilities for the decay of the 2_1^+ , 2_2^+ , 0_2^+ , 4_1^+ , 6_1^+ and 3_1^- states deduced

- No observation of the 0_3^+ state
- No observation of the 0_4^+ state

The ^{104}Pd isotope

- Experimental data on the electromagnetic structure are surprisingly scarce
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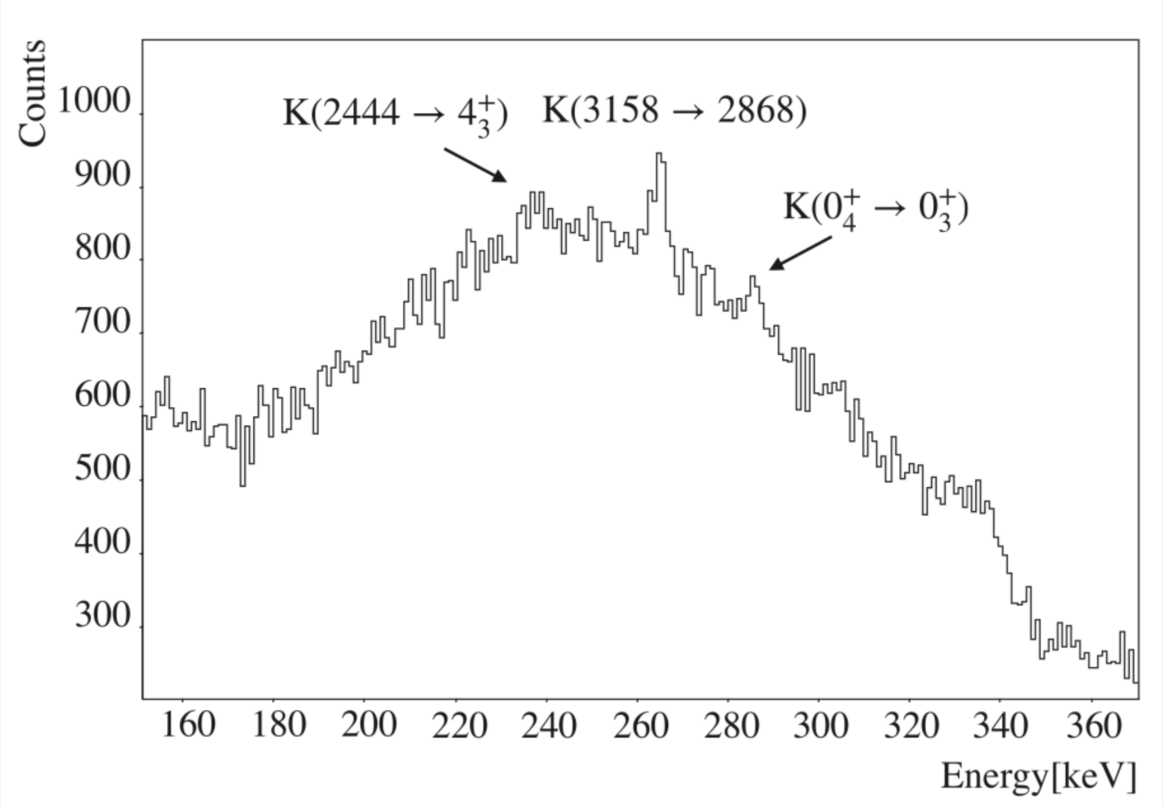
- Coulomb-excitation measurements performed with light beams leading to the population of a limited number of low-lying levels
- Spectroscopy of internal conversion electrons suggested the 0_4^+ state at 2101 keV



N. Marchini et al. Phys. Rev. C 105, 054304 (2022)

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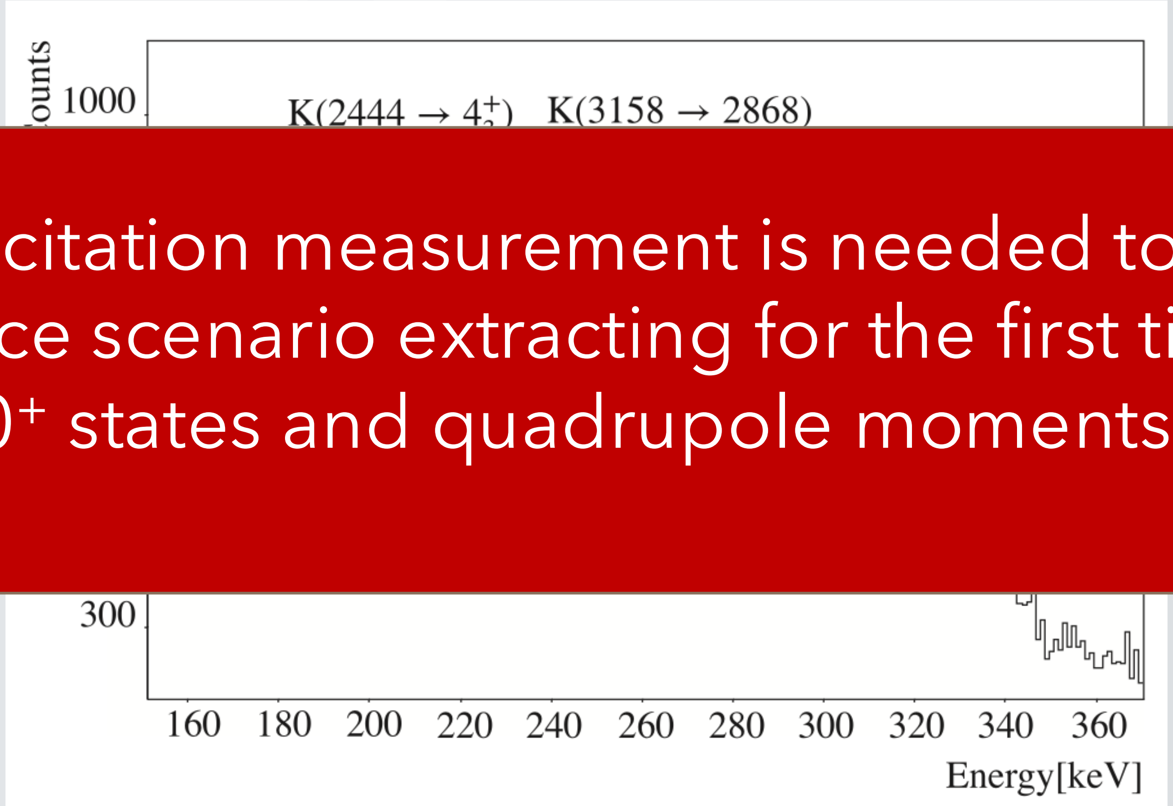

A new Coulomb excitation measurement is needed to study the possible shape coexistence scenario extracting for the first time deformation parameters of 0^+ states and quadrupole moments of the 2^+ states

N. Marchini et al. Phys. Rev. C 105, 054304 (2022)

The Proposed Experiment

Level	Energy [keV]	Transition	E_γ [keV]	Counts/8 hours
2_1^+	556	$2_1^+ \rightarrow 0_1^+$	556	7×10^6
4_1^+	1324	$4_1^+ \rightarrow 2_1^+$	768	4.7×10^5
2_2^+	1342	$2_2^+ \rightarrow 2_1^+$	786	4×10^4
		$2_2^+ \rightarrow 0_1^+$	1342	3.8×10^4
0_2^+	1334	$0_2^+ \rightarrow 2_1^+$	778	5.8×10^4
0_3^+	1793	$0_3^+ \rightarrow 2_1^+$	1237	1.1×10^5
		$0_3^+ \rightarrow 2_2^+$	451	874
2_3^+	1794	$2_3^+ \rightarrow 0_1^+$	1794	163
		$2_3^+ \rightarrow 2_1^+$	1238	1×10^4
		$2_3^+ \rightarrow 0_2^+$	460	157
4_2^+	2082	$4_2^+ \rightarrow 2_2^+$	740	2.9×10^3
		$4_2^+ \rightarrow 4_1^+$	758	1×10^3
		$4_2^+ \rightarrow 2_1^+$	1526	2.5×10^3
6_1^+	2250	$6_1^+ \rightarrow 4_1^+$	926	21
3_1^-	2194	$3_1^- \rightarrow 0_1^+$	2194	2.3×10^3

- Beam: ^{58}Ni, 1 pnA, 175 MeV
- Target: 1mg/cm^2 ^{104}Pd self-supporting

- AGATA (12 ATC) + SPIDER (123-161°)

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- Extract the 0^+ state deformation parameters using quadrupole sum rules

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GOALS:

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- Search for E2 transitions from 2^+ states on top of the 0_3^+ state and, in case of their existence, the first determination of the ⟨Q2⟩ invariant for the 0_3^+ state
- Study of the decay of the 0_4^+ state.

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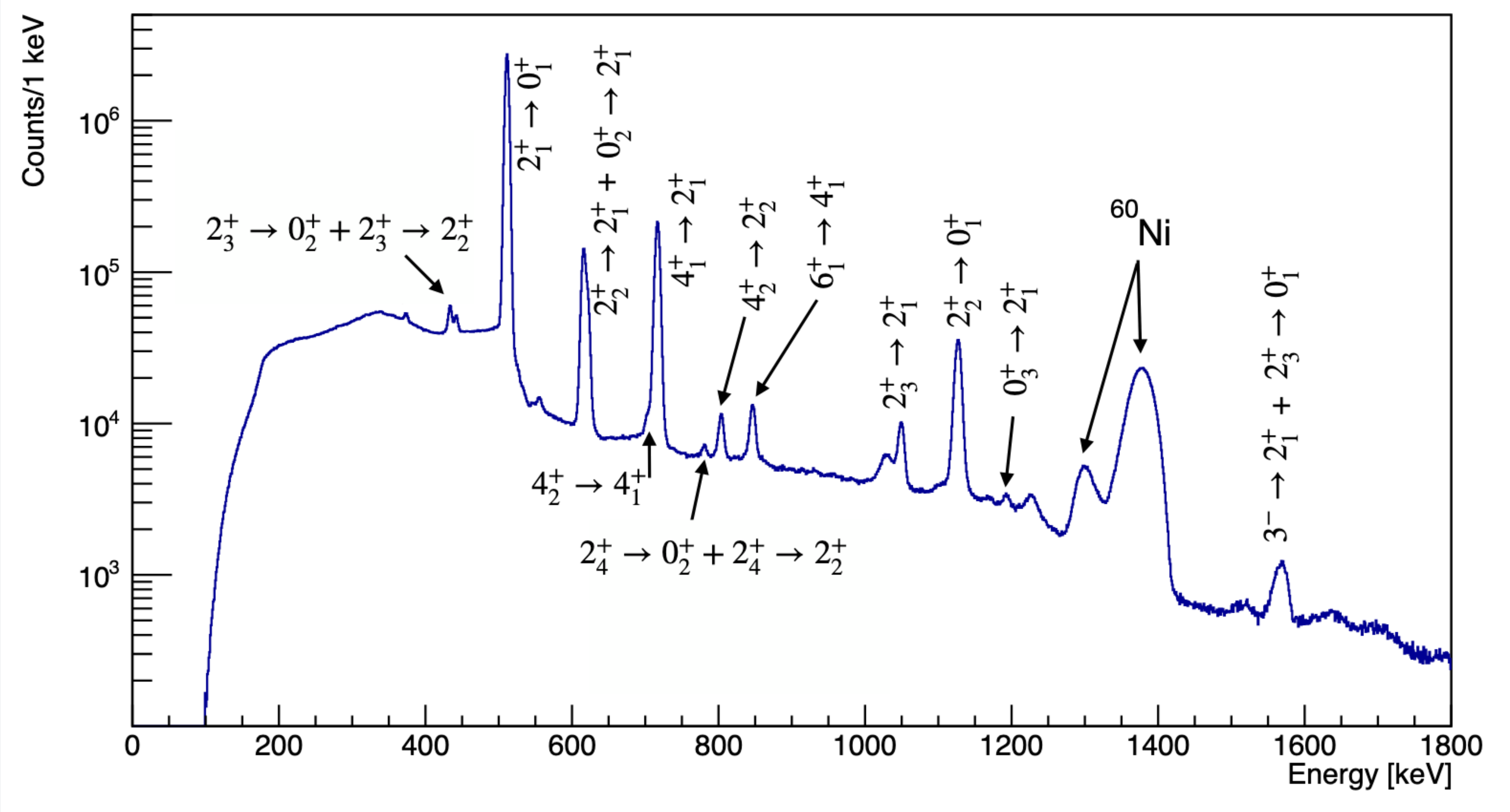
NEXT STEPS:

- Study all the possible sign combinations
- Ask for theoretical calculations

Thank You for your Attention

N. Marchini[1], A. Nannini[1], D. Kalaydjieva[2], I.Z. Piętka[3], M. Rocchini[1], P. Aguilera[4], G. Andreetta[4], F. Angelini[4], M. Balogh[4], J. Benito[4], G. Benzoni[5], D. Brugnara[6], G. Colucci[3], D. T. Doherty[7], A. Ertoprak[8], C. Fahlander[9], F. Galtarossa[10], P. E. Garrett[2], A. Goasduff[4], B. Gongora[4], A. Gottardo[4], A. Gozzelino[4], K. Hadyńska-Klęk[3], G. Jaworski[6], M. Komorowska[3], W. Korten[11], A. Krzysiek[14], M. Matejska-Minda[12], D. Mengoni[10,13], P. Napiorkowski[3], R. Nicolas del Alamo[4], J. Pellumaj[4], R. M. Perez-Vidal[15], S. Pigliapoco[4], E. Pilotto[4], M. Polettini[6], L. Prochniak[3], T. Rodríguez[16], M. Siciliano[8], K. Stoychev[2], D. Stramaccioni[4], G. Szymanek[14], J. J. Valiente-Dobón[4,15], K. Wrzosek-Lipska[3], L. Zago[4], M. Zielińska[11]

[1] *INFN Sezione di Firenze, Firenze, Italy.* [2] *University of Guelph, Guelph, Canada.* [3] *Heavy Ion Laboratory, University of Warsaw, Warsaw, Poland.* [4] *INFN Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy.* [5] *INFN Sezione di Milano, Milano, Italy.* [6] *GSI Darmstadt, Germany.* [7] *University of Surrey, Guildford, UK.* [8] *Argonne National Laboratory, Argonne, USA.* [9] *University of Lund, Lund, Sweden.* [10] *INFN Sezione di Padova, Padova, Italy.* [11] *IRFU, CEA Saclay, Université Paris-Saclay, France.* [12] *IFJ-PAN, Kraków, Poland.* [13] *Università degli Studi di Padova, Padova, Italy.* [14] *University of Warsaw, Warsaw, Poland.* [15] *IFIC, CSIC-Universidad de Valencia, Valencia, Spain.* [16] *Universidad Complutense de Madrid, Madrid, Spain.*


Counts/1 keV
10^6
10^5
10^4
10^3
$2_1^+ \to 0_1^+$
$2_3^+ \to 0_2^+ + 2_3^+ \to 2_2^+$
$2_2^+ \to 2_1^+ + 0_2^+ \to 2_1^+$
$4_1^+ \to 2_1^+$
$4_2^+ \to 2_2^+$
$6_1^+ \to 4_1^+$
$4_2^+ \to 4_1^+$
$2_4^+ \to 0_2^+ + 2_4^+ \to 2_2^+$
$2_3^+ \to 2_1^+$
$2_2^+ \to 0_1^+$
$0_3^+ \to 2_1^+$
^{60}Ni
$3^- \to 2_1^+ + 2_3^+ \to 0_1^+$
0
200
400
600
800
1000
1200
1400
1600
1800
Energy [keV]