In-beam Fast-Timing Measurements in Transitional and Triaxially Deformed Ru Isotopes

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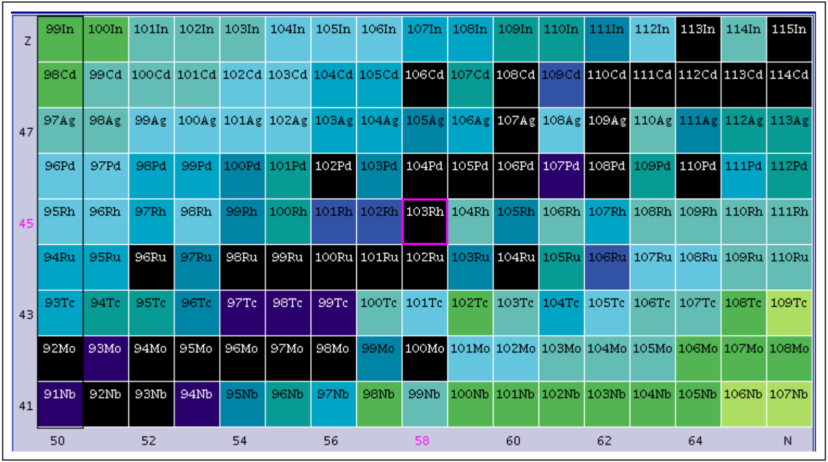
10.10.2015

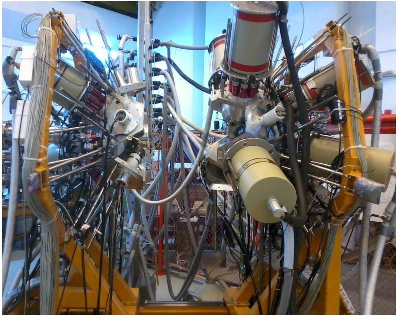
$A \sim 100$ mass region



ROSPHERE mixed detector array

ROSPHERE

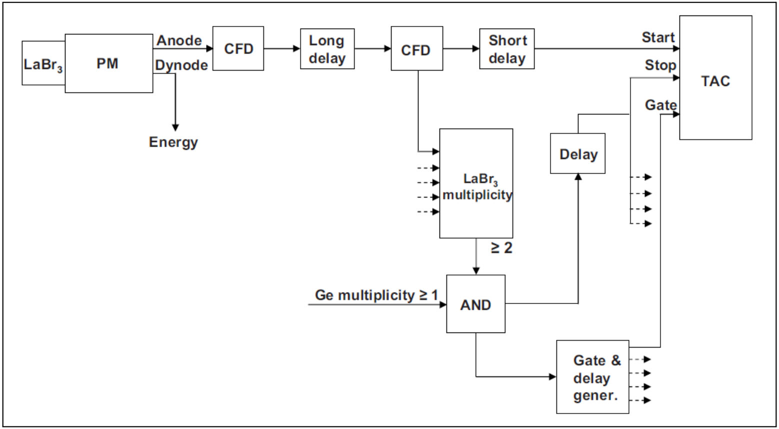
A mixed array of HPGe и $LaBr_3$:Ce detectors was used for γ -spectroscopy (Bucharest, Romania).



ROSPHERE detector array

- 14 HPGe detectors (good energy resolution)
- 11 $LaBr_3$:Ce detectors (good timing resolution)

Experimental set-up for fast-timing measurements



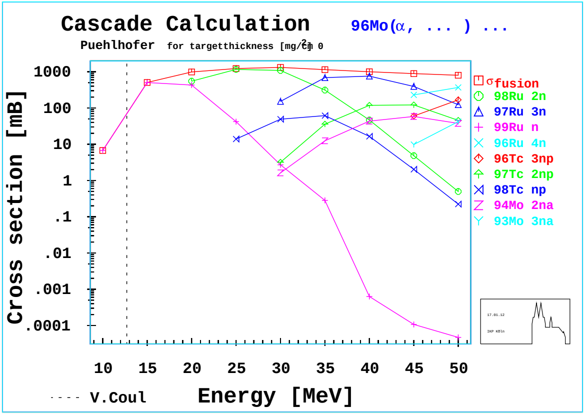
N. Mărginean *et al.*, Eur. Phys. J. A 46, 329–336 (2010)

Cross section for ^{96}Mo(α, nγ)^{99}Ru

^{96}Mo(α, nγ)^{99}Ru

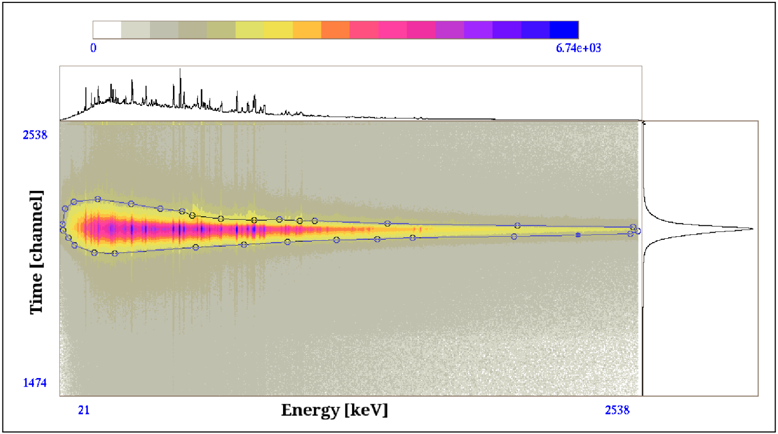
Target thickness: 10 mg/cm^2

E_{beam}= 15 MeV



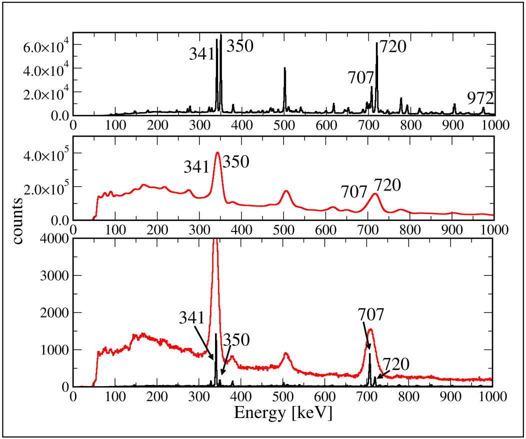
Gates on energy and time in HPGe

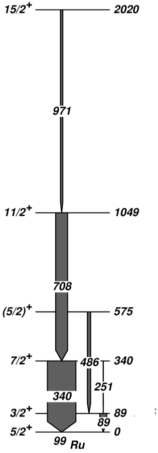
Two dimensional gates on energy and time are set in HPGe in order to reduce random coincidences.



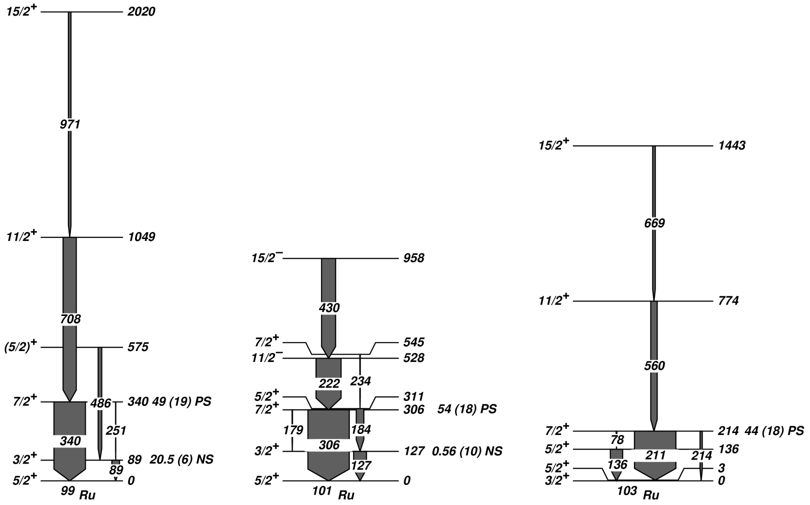
Energy spectra from ^{96}Mo(α, nγ)^{99}Ru

Applying an energy gate on HPGe detectors decreases the statistics in $LaBr_3$ spectra, but increases the peak-to background ratio for the levels of interest.

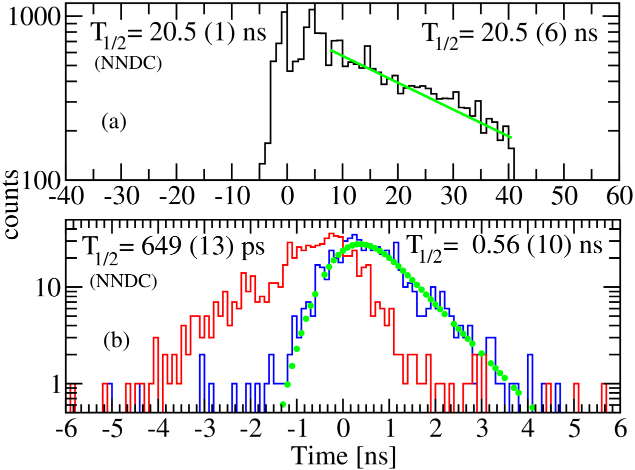




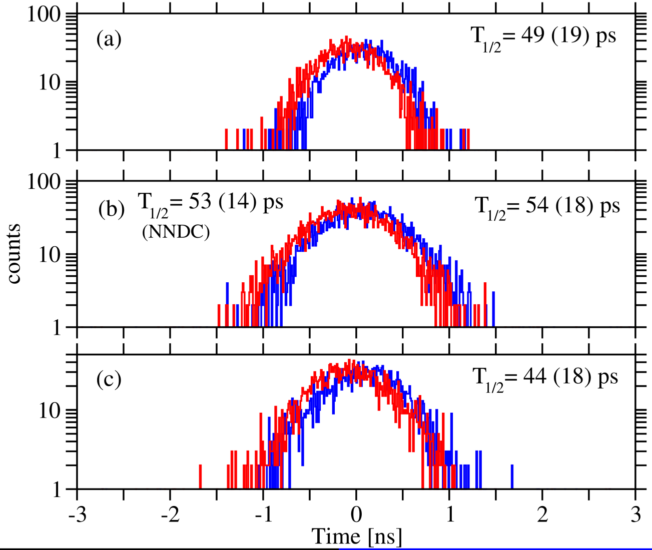
Low-lying states in ^{99,101,103}Ru



Half-lives of $3/2^{+}$ states in (a)^{99}Ru, (b)^{101}Ru



Half-lives of $7/2^+$ states in (a)^{99}Ru, (b)^{101}Ru, (c)^{103}Ru



Reduced Transition Probabilities

B(M1) and B(E2) values for $3/2^+ \rightarrow 5/2^+$ transitions in ^{99,101}Ru

Isotope	E_{level} [keV]	E_γ [keV]	$T_{1/2}$ [ns]	B(M1) [W.u.]	B(E2) [W.u.]
^{99}Ru	89	89	20.5 (6)	0.000175 (7)	50.1 (18)
^{101}Ru	127	127	0.56 (10)	0.016 (3)	20 (5)

B(M1) and B(E2) values for $7/2^+ \rightarrow 5/2^+$ transitions in ^{99,101,103}Ru

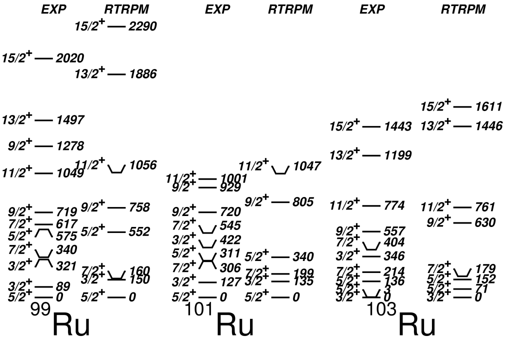
Isotope	E_{level} [keV]	E_γ [keV]	$T_{1/2}$ [ps]	B(M1) [W.u.]	B(E2) [W.u.]
^{99}Ru	340	340	49 (19)	0.011 (5)	0.036 (23)
^{101}Ru	306	306	54 (18)	0.014 (5)	1.3 (13)
^{103}Ru	214	211	44 (18)	...	...

Triaxial rotor plus particle calculations

$\kappa_4 = 0.070$
$\mu_4 = 0.39$
$\kappa_5 = 0.062$
$\mu_5 = 0.43$

nucleus	ϵ_2	γ
^{99}Ru	+0.149	28.0
^{101}Ru	+0.187	26.0
^{103}Ru	+0.230	26.0

ϵ_4=-0.04



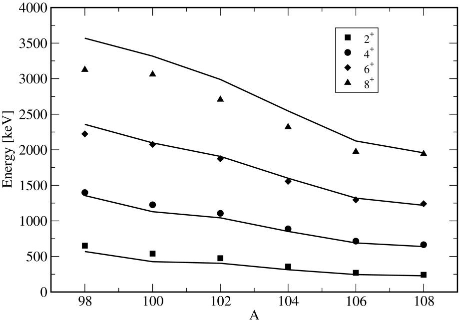
Triaxial rotor plus particle calculations

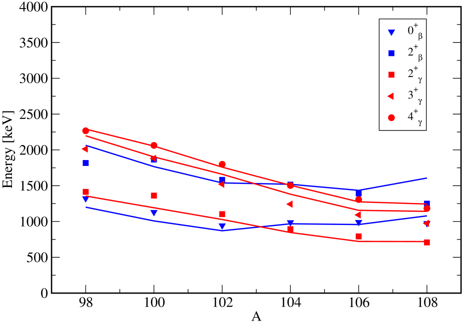
J_i^π	E_γ^{exp} (keV)	$B(M1)^{exp}$ (W.u.)	$B(M1)^{th}$ (W.u.)	$B(E2)^{exp}$ (W.u.)	$B(E2)^{th}$ (W.u.)	μ_{exp} μ_N	μ_{th} μ_N	Q_{exp} (b)	Q_{th} (eb)
$^{99}_{44}$**Ru**									
$5/2^+$	0					-0.641 (5)	-0.954	0.079 (4)	-0.008
$3/2^+$	0					-0.284 (6)	0.001	0.231 (13)	0.123
$3/2^+$	89	0.00018 (7)	0.024	50.1 (18)	22.4				
$7/2^+$	340	0.011 (5)	0.0008	0.036 (23)	0.12				
	251			3.0 (12)	2.4				
$^{101}_{44}$**Ru**									
$5/2^+$	0					-0.719 (6)	-0.801	0.46 (2)	0.109
$3/2^+$	0					-0.210 (5)	-0.272		
$3/2^+$	127	0.016 (3)	0.008	20 (5)	0.03				
$7/2^+$	306	0.014 (5)	0.002	1.3 (13)	0.02				
	179			13 (5)	22.5				
$^{103}_{44}$**Ru**									
$3/2^+$	0					0.200 (7)	0.415	0.62 (2)	0.491
$7/2^+$	214			46 (19)	13				
	211	0.048 (20)	0.007						
	78	0.017 (8)	0.002						

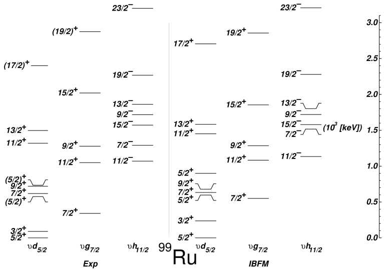
IBM-1 calculations of Ru even-even cores

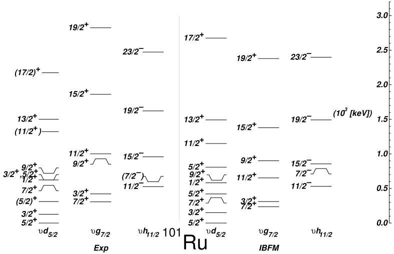
Extended Consistent-Q Formalism

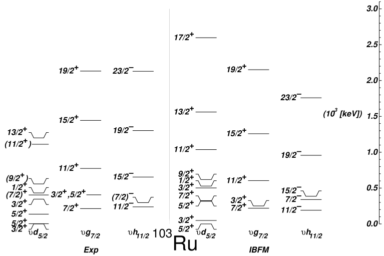
$$H = \epsilon \widehat{n_d} - \kappa Q^2 - \kappa' L^2$$

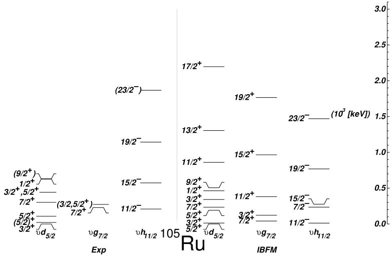





99Ru
Exp
IBFM
νd5/2
νg7/2
νh11/2
(10³ [keV])


101Ru
Exp
IBFM
νd5/2
νg7/2
νh11/2
(10³ [keV])


103Ru
Exp
IBFM
νd5/2
νg7/2
νh11/2
(10³ [keV])


105Ru
Exp
IBFM
νd5/2
νg7/2
νh11/2
(10³ [keV])

Experimental and IBFM-1 spectroscopic factors for (d,p)

	$E^{\dagger}_{level}$ [keV]	$J^{\pi\,\dagger}$	$C^2S'_{exp}$	$C^2S'_{th}$		$E^{\dagger}_{level}$ [keV]	$J^{\pi\,\dagger}$	$C^2S'_{exp}$	$C^2S'_{th}$
^{99}Ru	0.0	$5/2^+$		3.14	^{103}Ru	0.0	$3/2^+$	1.44	0.010
^{99}Ru	89.57	$3/2^+$		0.008	^{103}Ru	2.81	$5/2^+$	1.35	2.20
^{99}Ru	340.90	$7/2^+$		2.97	^{103}Ru	136.079	$5/2^+$	0.012	0.13
^{99}Ru	575.83	$(5/2)^+$		0.03	^{103}Ru	174.26	$1/2^+$	0.75	1.15
^{99}Ru	618.13	$(1/2^+)$		0.85	^{103}Ru	213.56	$7/2^+$	1.80	3.70
^{99}Ru	734.09	$(5/2)^+$		0.005	^{103}Ru	238.2	$11/2^-$	3.2	7.08
^{99}Ru	1069.88	$11/2^-$		8.86	^{103}Ru	346.38	$3/2^+$	0.06	0.005
					^{103}Ru	404.15	$7/2^+$		0.006
					^{103}Ru	432.06	$1/2^+$	0.027	0.048
^{101}Ru	0.0	$5/2^+$	2.10	2.10	^{105}Ru	0.0	$3/2^+$	0.009	0.13
^{101}Ru	127.229	$3/2^+$	0.067	0.014	^{105}Ru	20.610	$(5/2)^+$	1.54	1.75
^{101}Ru	306.858	$7/2^+$	5.3	4.13	^{105}Ru	107.937	$5/2^+$	0.07	0.31
^{101}Ru	311.368	$5/2^+$		0.07	^{105}Ru	159.518	$1/2^+$	0.74	0.96
^{101}Ru	325.23	$1/2^+$	0.96	1.13	^{105}Ru	208.6	$11/2^-$	2.7	6.19
^{101}Ru	422.22	$3/2^+$	0.15	0.66	^{105}Ru	229.48	$7/2^+$	0.75	3.45
^{101}Ru	527.56	$11/2^-$	5.82	7.69	^{105}Ru	272.722	$(3/2,5/2^+)$		0.31
^{101}Ru	545.115	$7/2^+$		0.003	^{105}Ru	301.68	$7/2^+$	0.24	0.03
^{101}Ru	616.30	$5/2^+$		0.08	^{105}Ru	631.27	$1/2^+$	0.06	0.13
^{101}Ru	623.59	$1/2^+$	0.063	0.021					

† from NNDC

Experimental and IBFM-1 transition probabilities

Isotope	E_{level} [keV]	J_i^π	E_γ [keV]	J_f^π	B(M1)$_{exp}$ [W.u.]	B(E2)$_{exp}$ [W.u.]	B(M1)$_{IBFM}$ [W.u.]	B(E2)$_{IBFM}$ [W.u.]
^{99}Ru	89.57	$3/2^+$	89.50	$5/2^+$	0.000175 (4)	50.1 (10)	0.000169	31.0
^{99}Ru	340.90	$7/2^+$	340.81	$5/2^+$	0.011 (5)	0.036 (23)	0.001	11
			251.0	$3/2^+$		3.0 (12)		2
^{99}Ru	575.83	$(5/2)^+$	486.19	$3/2^+$	0.11 (3)	0.18 +53-18	0.57	3.78
			575.75	$5/2^+$	0.035 (10)	11 (5)	0.001	23
^{99}Ru	617.89	$7/2_2^+$	528.36	$3/2^+$		120 (7)		3
			617.89	$5/2^+$	0.09 (6)	23 (18)	0.002	15
^{99}Ru	719.87	$9/2^+$	379.07	$7/2^+$	0.0045 (8)	3 +4-3	0.052	6.9
			719.81	$5/2^+$		46 (6)		26
^{99}Ru	1048.50	$11/2^+$	328.57	$9/2^+$	0.011 (7)	2.9 (17)	0.0004	0.1
			707.56	$7/2^+$		23 (13)		19
^{99}Ru	1497.06	$13/2^+$	777.25	$9/2^+$		110 (6)		38
^{99}Ru	2020.29	$15/2^+$	971.95	$11/2^+$		61 (25)		40
^{99}Ru	3094.45	$(19/2)^+$	1074.14	$15/2^+$		35 +14-29		40
^{101}Ru	127.229	$3/2^+$	127.226	$5/2^+$	0.01598 (11)	19.9 (24)	0.052	31.4
^{101}Ru	306.858	$7/2^+$	179.636	$3/2^+$		13 (4)		2
			306.857	$5/2^+$	0.014 (4)	1.4 +15-4	0.001	0.8
^{101}Ru	720.02	$9/2^+$	720.02	$5/2^+$		40 (10)		31
^{101}Ru	1500.9	$13/2^+$	780.9	$9/2^+$		120 (4)		48
^{101}Ru	1862.4	$15/2^+$	861.2	$11/2^+$		<25		57

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Thank you for your attention