



# The Evolution of Triaxiality in the Mass 110 Region

---

Johannes Sørby Heines

University of Oslo

5th of May 2026

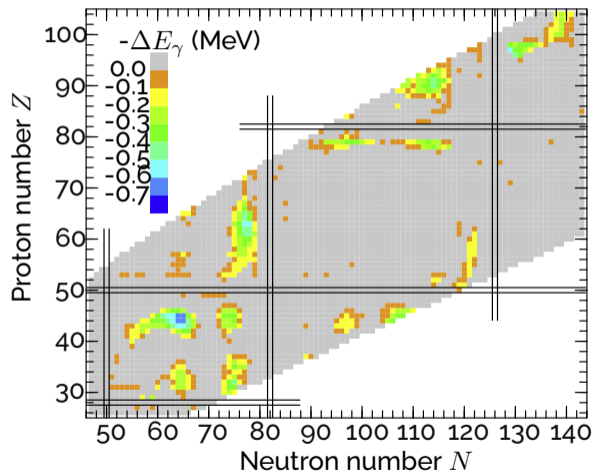
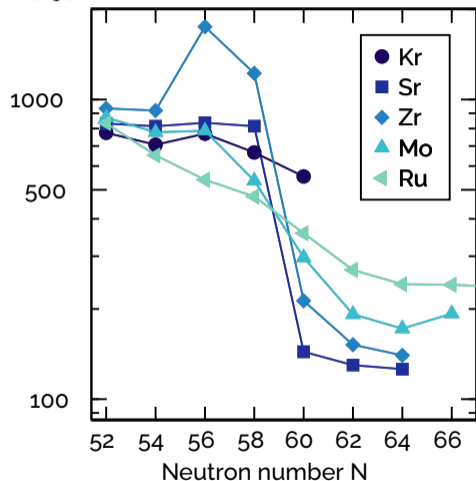


Funded by  
The Research  
Council of Norway



# The Mass 110 Region

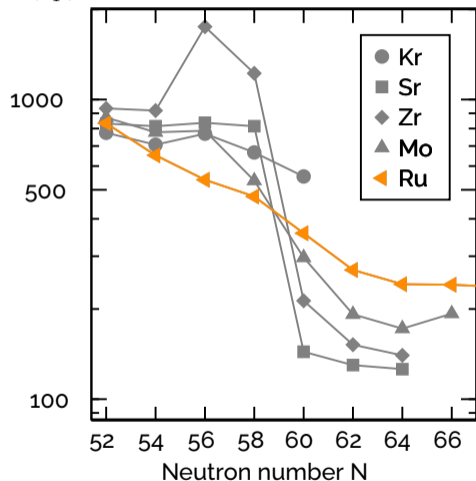
$E(2_1^+) / \text{keV}$



A. Gorgen & W. Korten, J Phys G 43, 024002 (2016)

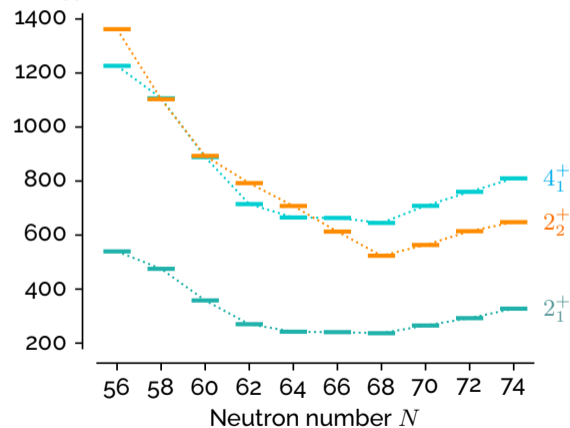
P.Moller et al. At Data Nucl Data Tables 94, 758 (2008)

$E(2_1^+) / \text{keV}$



Lowering of the  $\gamma$  band

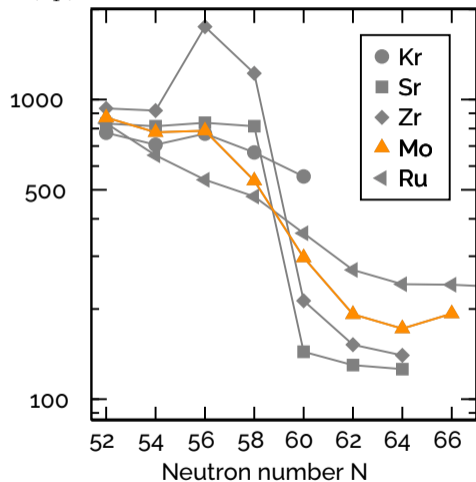
Energy / keV



A. Gorgen & W. Korten, J Phys G 43, 024002 (2016)

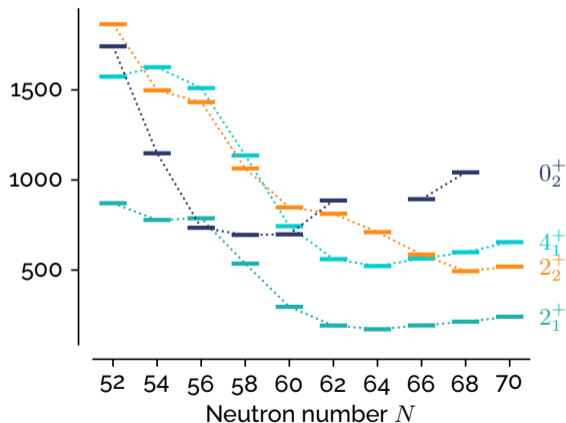
P.A.Soderstrom at al. PRC 88, 024301 (2013)

$E(2_1^+) / \text{keV}$



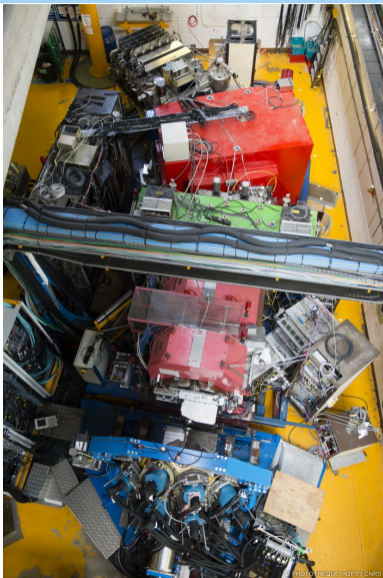
Both shape coexistence and triaxiality

Energy / KeV

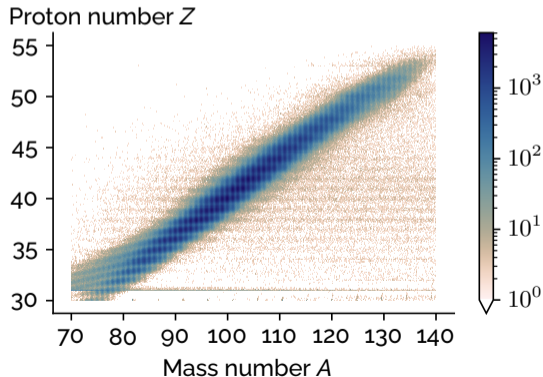


A. Gørgen & W. Korten, J Phys G 43, 024002 (2016)

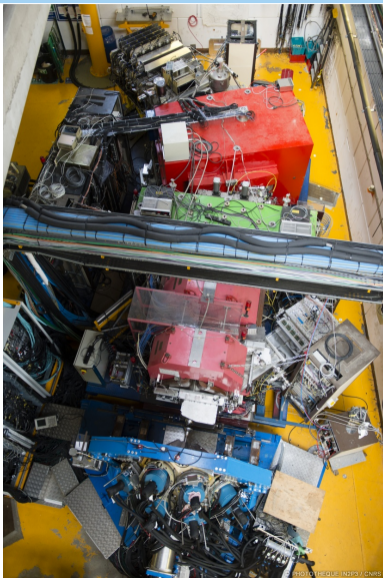
# AGATA & VAMOS++ @ GANIL



event-by-event particle identification  
velocity measurement  
 $\gamma$ -ray tracking



# AGATA & VAMOS++ @ GANIL

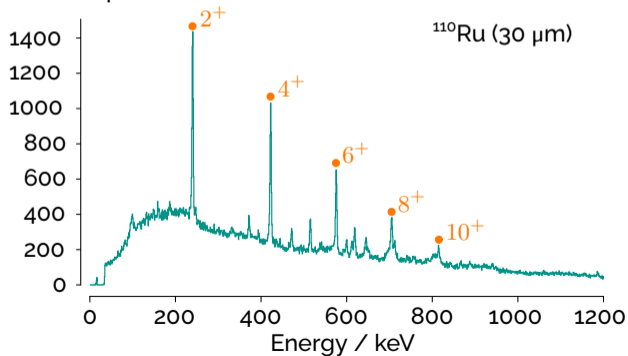


event-by-event particle identification

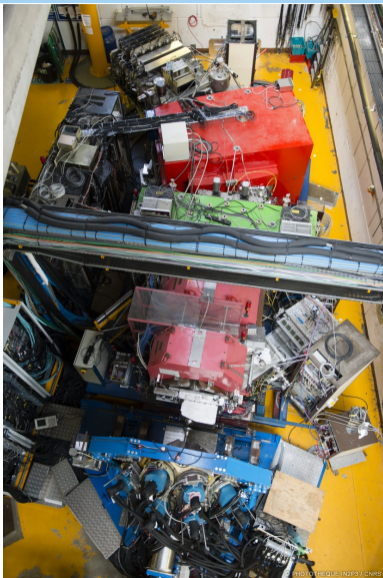
velocity measurement

$\gamma$ -ray tracking

Counts per keV



# AGATA & VAMOS++ @ GANIL

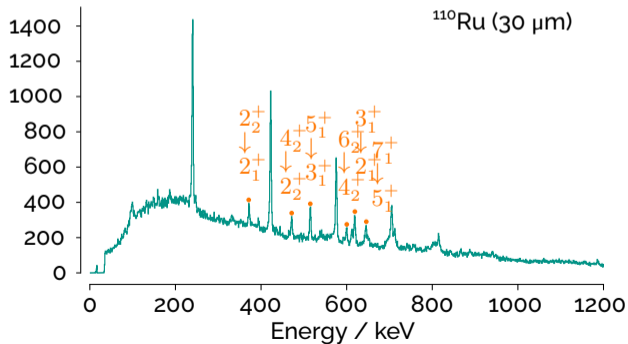


event-by-event particle identification

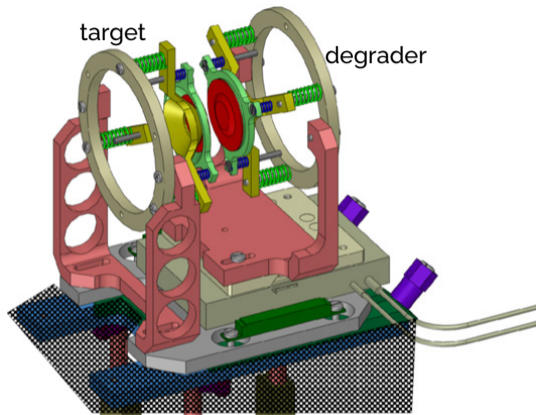
velocity measurement

$\gamma$ -ray tracking

Counts per keV

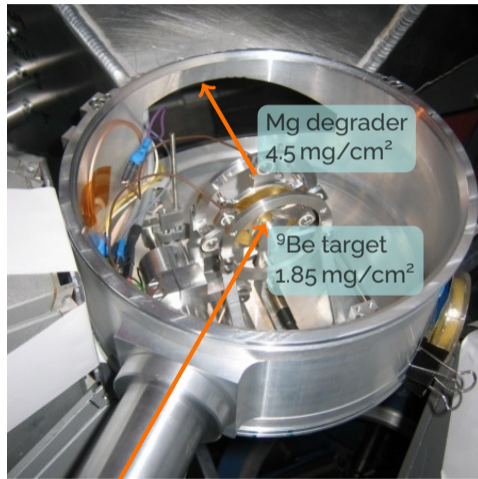


# Recoil Distance Doppler Shift Method



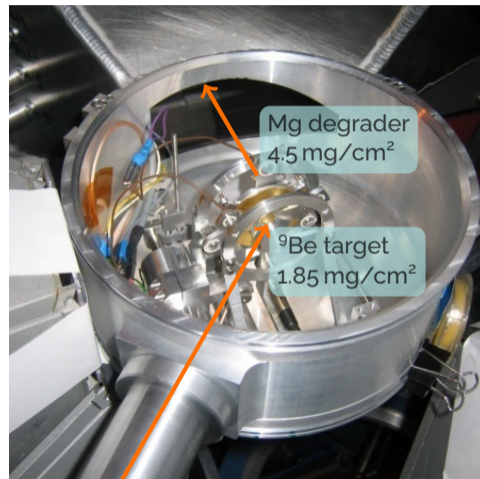
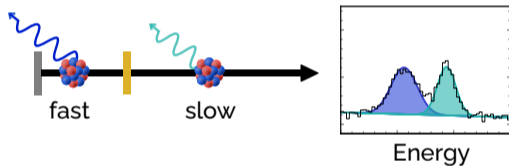
Orsay Universal Plunger System

J. Ljungvall et al. NIM A 679, 61 (2012)



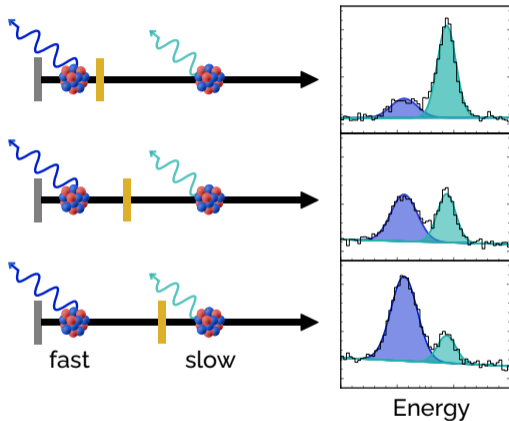
$^{238}\text{U}$  at 6.2 meV/u

# Recoil Distance Doppler Shift Method



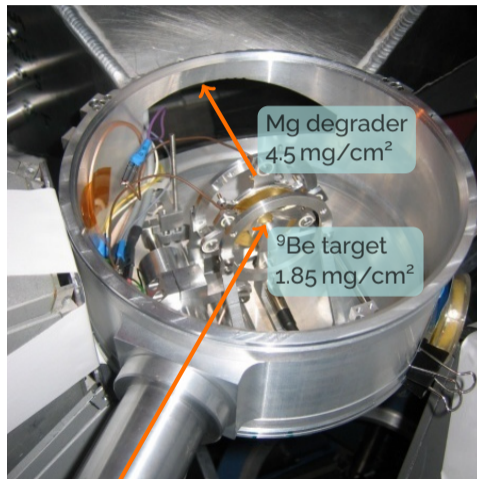
<sup>238</sup>U at 6.2 meV/u

# Recoil Distance Doppler Shift Method



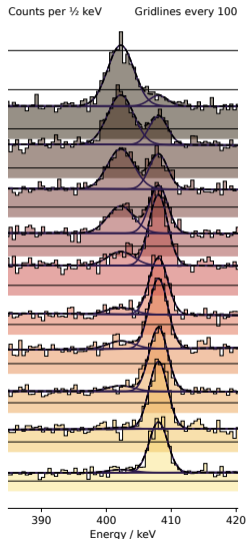
10 distances: 43–2664  $\mu\text{m}$

$\sim 18$  h per distance



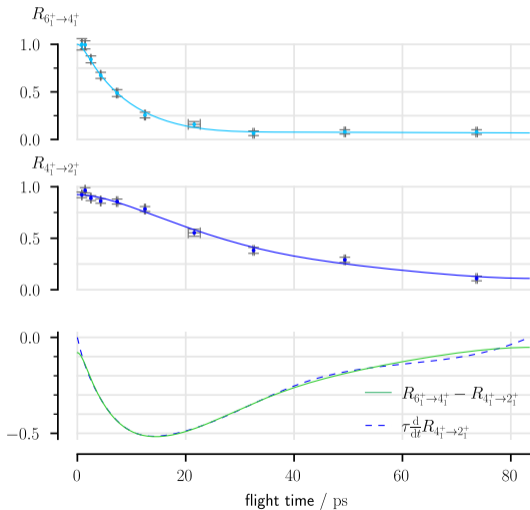
<sup>238</sup>U at 6.2 meV/u

# Recoil Distance Doppler Shift Method



$R = \text{slow fraction}$

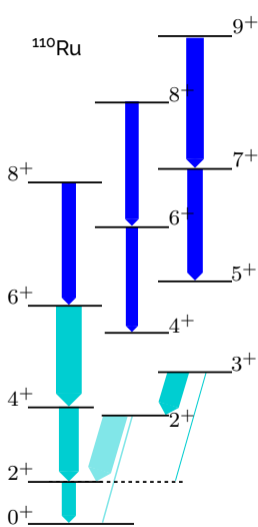
$$\tau = \frac{\sum_h \alpha R_{h \rightarrow i} - R_{i \rightarrow j}}{\frac{dR_{i \rightarrow j}}{dt}}$$



# Ruthenium

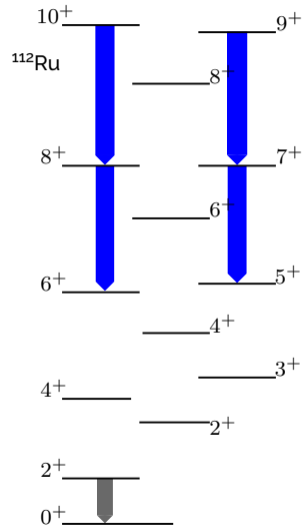
## Doppler shift attenuation

B.Snyder et al.  
PLB 723, 61 (2013)



## Coulomb excitation

D.T.Doherty et al.  
PLB 766, 334 (2017)



## Doppler profile method

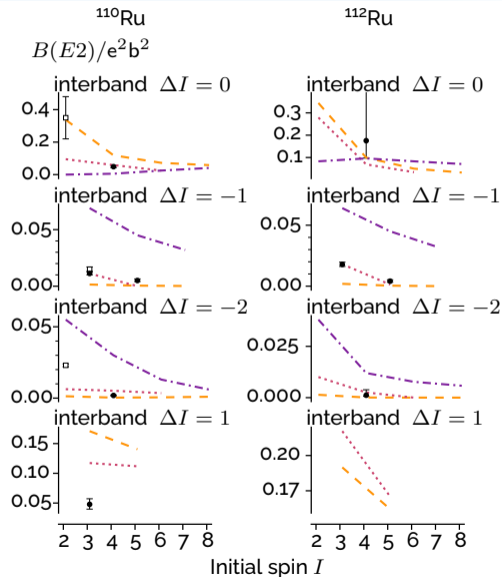
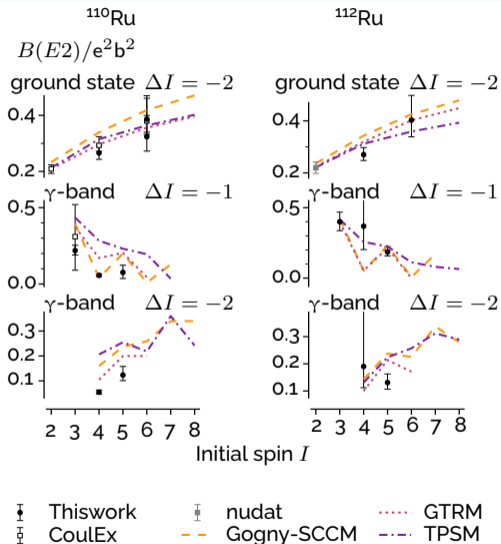
A.G.Smith et al.  
PRC 86, 014321 (2012)

## Lifetime measurement

R.C.Jared et al.  
LBNL-2366, p.38 (1984)



# Ruthenium

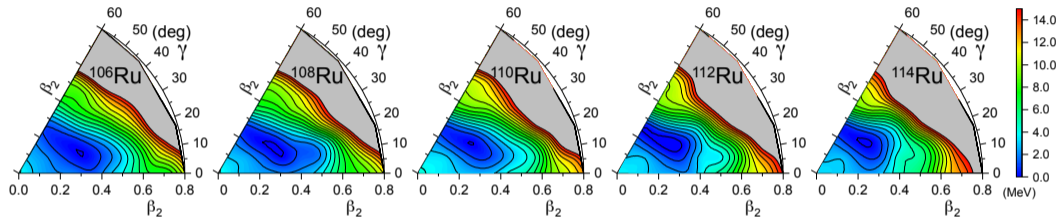


S.P.Rouoof et al. EPJA 60, 40 (2024)

# Ruthenium

## Microscopic calculations

T.R.Rodriguez & J.L.Egido, PRC 81, 864323 (2010)



## Fitted phenomenological models

	$\beta$	$\gamma$
$^{109}\text{Ru}$	0.33	18
$^{110}\text{Ru}$	0.30	23
$^{111}\text{Ru}$	0.38	27
$^{112}\text{Ru}$	0.31	26

even-even: Generalized Triaxial Rotor Model

J.L.Wood et al. PRC 70, 024308 (2004)

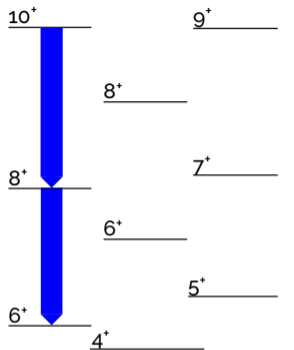
odd-neutron: Triaxial Particle-Rotor Model

I.Ragnarsson & P.B.Semmes, Hyperfine Interact 43, 423 (1988)

# Molybdenum

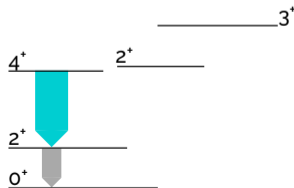
## Doppler profile method

A.G.Smith et al.  
PRC 86, 014321 (2012)



## Doppler shift attenuation

D.Ralet et al.  
PRC 95, 034320 (2017)



## $\beta$ decay timing

J.Ha et al.  
PRC 101, 044311 (2020)

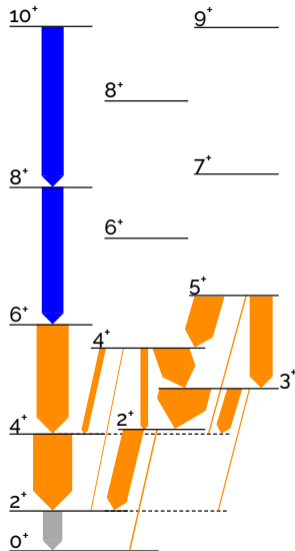
# Molybdenum

## Doppler profile method

A.G.Smith et al.  
PRC 86, 014321 (2012)

## Doppler shift attenuation

D.Ralet et al.  
PRC 95, 034320 (2017)



## $\beta$ decay timing

J.Ha et al.  
PRC 101, 044311 (2020)

# Thank you

J. S. Heines<sup>1,2</sup> V. Modamio<sup>1,2</sup> A. Görgen<sup>1,2</sup> W. Korten<sup>3</sup> E. Clément<sup>4</sup> J. Dudouet<sup>5</sup> A. Lemasson<sup>4</sup> J. Ljungvall<sup>6,7</sup> J. M. Allmond<sup>8</sup>  
T. R. Rodríguez<sup>9</sup> S. Ansari<sup>3</sup> T. Arici<sup>10</sup> K. S. Beckmann<sup>1</sup> A. M. Bruce<sup>11</sup> D. Doherty<sup>12</sup> A. Esmaylzadeh<sup>13</sup> E. R. Gamba<sup>11</sup> L. Gerhard<sup>13</sup>  
J. Gerl<sup>10</sup> G. Georgiev<sup>6</sup> D. P. Ivanova<sup>14</sup> J. Jolie<sup>13</sup> Y.-H. Kim<sup>4</sup> L. Knafla<sup>13</sup> A. Korichi<sup>6</sup> P. Koseoglou<sup>10</sup> M. Labiche<sup>15</sup> S. Lalkovski<sup>14</sup>  
T. Lauritsen<sup>16</sup> H.-J. Li<sup>4</sup> G. Pasqualato<sup>6</sup> L. G. Pedersen<sup>1</sup> S. Pietri<sup>10</sup> D. Ralet<sup>6</sup> J. M. Regis<sup>13</sup> M. Rudigier<sup>12</sup> S. Saha<sup>10</sup> E. Sahin<sup>1,2</sup>  
S. Siem<sup>1,2</sup> P. Singh<sup>3</sup> P.-A. Söderström<sup>10,17,18</sup> C. Theisen<sup>3</sup> T. Tornyi<sup>19</sup> M. Vandebrouck<sup>3</sup> W. Witt<sup>17</sup> M. Zielinska<sup>3</sup>  
And the AGATA, FATIMA and VAMOS collaborations.

<sup>1</sup>University of Oslo, Norway

<sup>2</sup>Norwegian Nuclear Research Centre, Norway

<sup>3</sup>IRFU, CEA, Université Paris-Saclay, France

<sup>4</sup>GANIL, CEA/DRF-CNRS/IN2P3, France

<sup>5</sup>Université Claude Bernard Lyon-1, CNRS/IN2P3, IP2I, France

<sup>6</sup>Université Paris-Saclay, IJCLab, IN2P3/CNRS, France

<sup>7</sup>Université de Strasbourg, CNRS, IPHC, France

<sup>8</sup>Oak Ridge National Laboratory, USA

<sup>9</sup>Universidad de Sevilla, Spain

<sup>10</sup>GSI, Germany

<sup>11</sup>Brighton University, UK

<sup>12</sup>University of Surrey, UK

<sup>13</sup>Universität zu Köln, Germany

<sup>14</sup>Sofia University 'St. Kliment Ohridski', Bulgaria

<sup>15</sup>STFC Daresbury Laboratory, UK

<sup>16</sup>Argonne National Laboratory, USA

<sup>17</sup>TU Darmstadt, Germany

<sup>18</sup>ELI-NP/IFIN-HH, Romania

<sup>19</sup>HUN-REN Institute for Nuclear Research (ATOMKI), Hungary

- ▶ RDDS lifetime measurements
- ▶  $\gamma$ -ray tracking in AGATA
- ▶ event by event identification in VAMOS++

<sup>108–112</sup>Ru 16 lifetimes  $\Rightarrow$  26  $B(E2)$  values  
Fitted and microscopic calculations  
Increasing triaxiality

J.S.Heines et al. EPJA 62, 38 (2026)

<sup>108</sup>Mo 6 lifetimes  $\Rightarrow$  14  $B(E2)$  values

Coming soon