Spectroscopy of the neutron-deficient ^{200}Po isotope by Coulomb excitation

using REX-ISOLDE, RILIS and the Ge MINIBALL array

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Correlated talks : Nick Bree *(Coulex of Hg)* & **Maxim Seliverstov** *($\delta\langle r^2\rangle$ of Po)*

20 November 2009, CERN, Switzerland

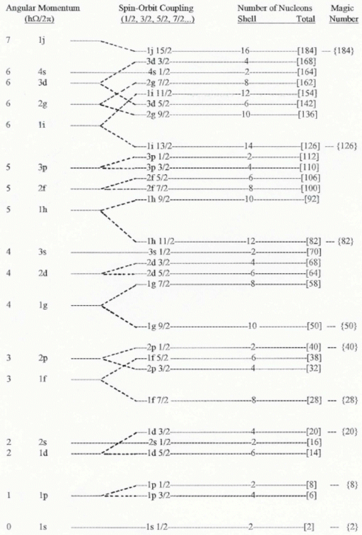
Shape coexistence in the lead region

Subtle interplay of 3 main effects

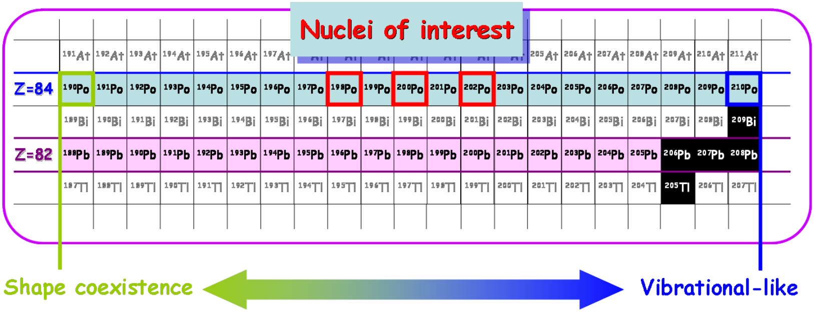
- π **side : energy gap of 3.9 MeV above Z=82 shell closure**
  Promote over spherical shape in ground state
- π **side : proton-pair excitation across the gap**
  Extra valence proton particles and holes
- ν **side : large valence space between N=82 and N=126**
  Large neutron valence number at N=104 mid-shell

Enables the ν-π quadrupole-quadrupole force to **lower the excitation of np-mh configurations**

Table 1 -- Nuclear Shell Structure (from *Elementary Theory of Nuclear Shell Structure*, Maria Goeppert Mayer & J. Hans D. Jensen, John Wiley & Sons, Inc., New York, 1955.)



Neutron-deficient Polonium isotopes

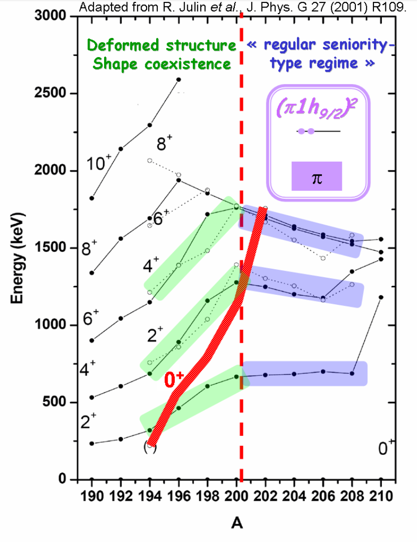


Aim : study the transition from vibrational-like to shape coexistence

Measure eletromagnetic transition probabilities via the Coulomb excitation

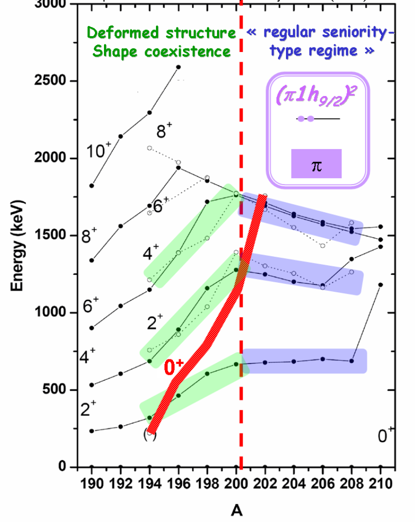
→ **Extract information about the nature of collectivity and configuration mixing**

Experimental investigations (not exhaustive)

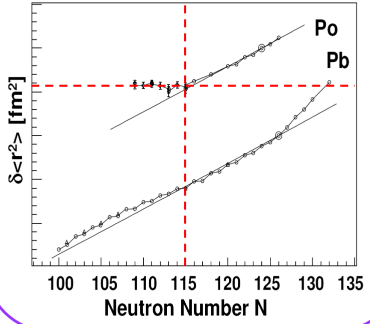


Experimental investigations (not exhaustive)

Adapted from R. Julin *et al.*, J. Phys. G 27 (2001) R109.



Change in the mean square charge radii



T.E. Cocolios, Ph.D. thesis work, University of Leuven

^{200}Po nucleus appears clearly as a **transition point**

Experimental investigations (not exhaustive)

Recoil distance Doppler-shift lifetime measurement using the recoil-decay tagging

- **^{194}Po**

  T. Grahn et al., Phys. Rev. Lett. 97 (2006) 062501

  T. Grahn et al., Nucl. Phys. A 801 (2008) 83.

E_γ [keV]	I_i^π	τ [ps]	B(E2) [W.u.]	$\lvert Q_t \rvert$ [eb]	$\lvert \beta_2^{(t)} \rvert$
319.7	2^+	37(7)	90(20)	5.5(6)	0.18(2)
366.5	4^+	14(4)	120(40)	5.4(8)	0.17(3)

The oblate component could dominate the ground state

- **^{196}Po**

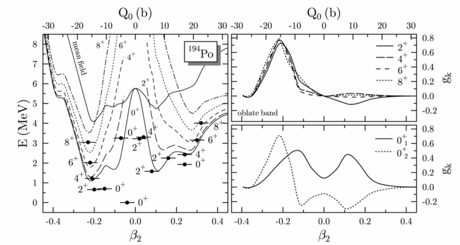
  T. Grahn et al., Phys. Rev. C 80 (2009) 014323

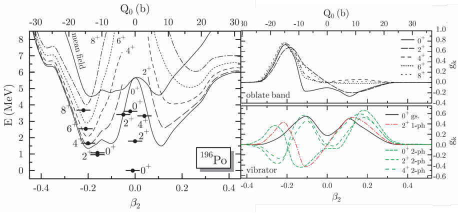
E_γ (keV)	I_i^π	τ_{final} (ps)	$B(E2)$ (W.u.)	$\lvert Q_t \rvert$ (eb)	$\lvert \beta_2^{(t)} \rvert$
463.1	2^+	11.7(15)	47(6)	4.0(3)	0.129(9)
427.9	4^+	7.8(11)	103(15)	4.9(4)	0.16(2)
499.1	6^+	2.9(12)	130(60)	5.3(11)	0.17(4)

2+ and 4+ being predominantly intruder character

Mixing of the spherical and oblate structures in the ground state

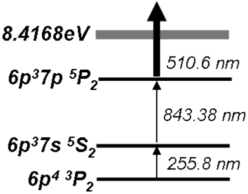
Configuration mixing calculations of angular momentum projected mean-field states





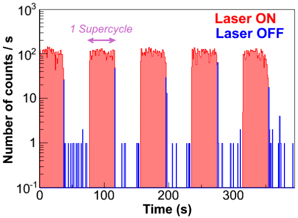
Beam production and characteristic

- 1.4 GeV proton beam ($\sim$0.9 μA)
- UCx target + W-Ta mixed cavity
- $^{200}Po^{+}$ resonantly ionized with the following 3-step ionization scheme

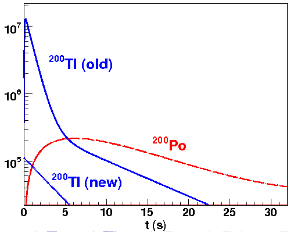


- $^{200}Po^{48+}$ post-accelerated at 2.85 MeV/u with 5% transmission for REX (β=0.078) $\Rightarrow$ **heaviest beam using RILIS**
- Reached $\sim 10^6$ pps on Miniball with 1.1μA proton beam intensity

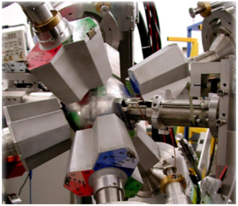
Obtained a beam purity of 98.8(9)%

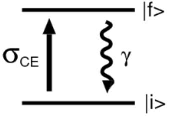


In agreement with the expectations



Coulomb excitation setup and method





$$\sigma_{E2} = \frac{N_\gamma^{coulex}}{N_{inc} N_{cible/cm^2}}$$

$$\sigma_{E2} \simeq \left(\frac{Z_c e^2}{\hbar c}\right)^2 \frac{\pi}{e^2 b_0^2} B(E2)$$

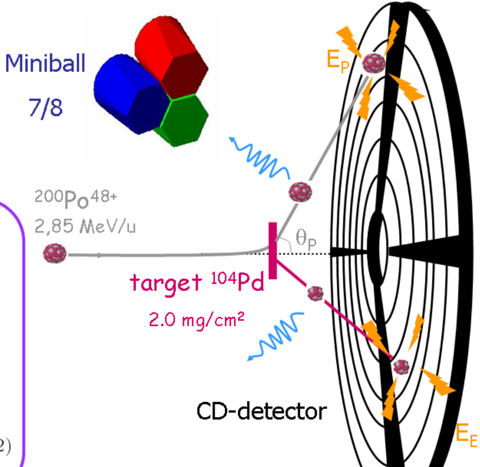
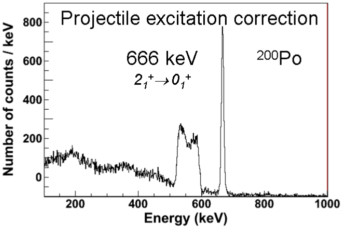
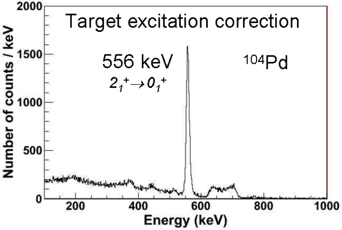


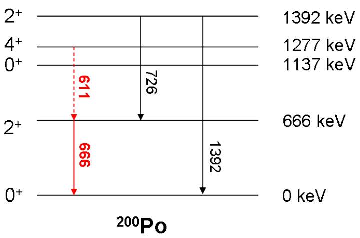
Figure : courtesy of N. Bree,
Ph.D. thesis work, University of Leuven.

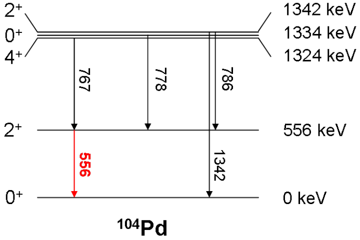
Doppler corrected background subtracted spectra



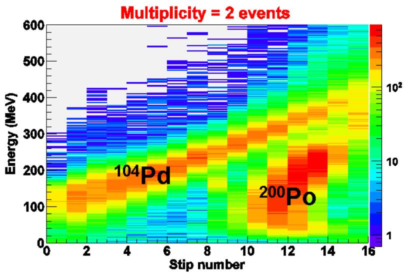


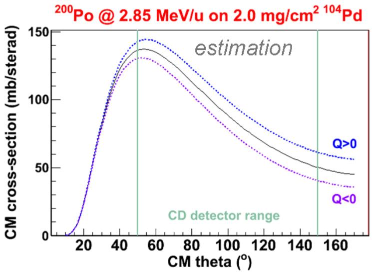
Extract the B(E2) value of the $2^+ \rightarrow 0^+$ transition of ^{200}Po





Projectile-ejectile separation in the CD-detector





- Very good ejectile-projectile separation
- Covering the angular region in the CM sensitif to the quadrupole moment
- Enough statistics to perform an acurate study

$\Rightarrow$ extract the signe of the quadrupole moment (cf N. Bree talk)

Summary and outlook

- Successful IS479-phase I run, where $^{200}Po^{48+}$ beam has been post-accelated for the first time at ISOLDE. **Heaviest post-accelerated beam using RILIS.**
- **The analysis of the data is in progress** (thoroughly check selections and calibration, cross checks, determine the efficiency curve, angular distribution corrections,CLX/GOSIA calculations...)
- In the future, combined with the **spectroscopy of ^{198}Po and ^{202}Po** using the same technique, the **obtained reduced transition matrix elements will be compared to beyond mean field models**, and will serve as important bench marks to test of the model and interactions used.

IS479 Collaboration

- **CERN-ISOLDE, Switzerland**
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