Lifetime measurements with JUROGAM

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OUTLINE

- Facility for RDT studies at JYFL
- RDDS measurements with JUROGAM + RITU
- The first RDDS lifetime measurements utilising the RDT method
- ^{180,182}Hg experiment – complementary Coulomb excitation studies at REX-ISOLDE
- ^{195,196}Po experiment – probing the collectivity as a function of *N*
- New results from the latest ^{167,168}Os lifetime measurements (autumn 2007)
- Outlook

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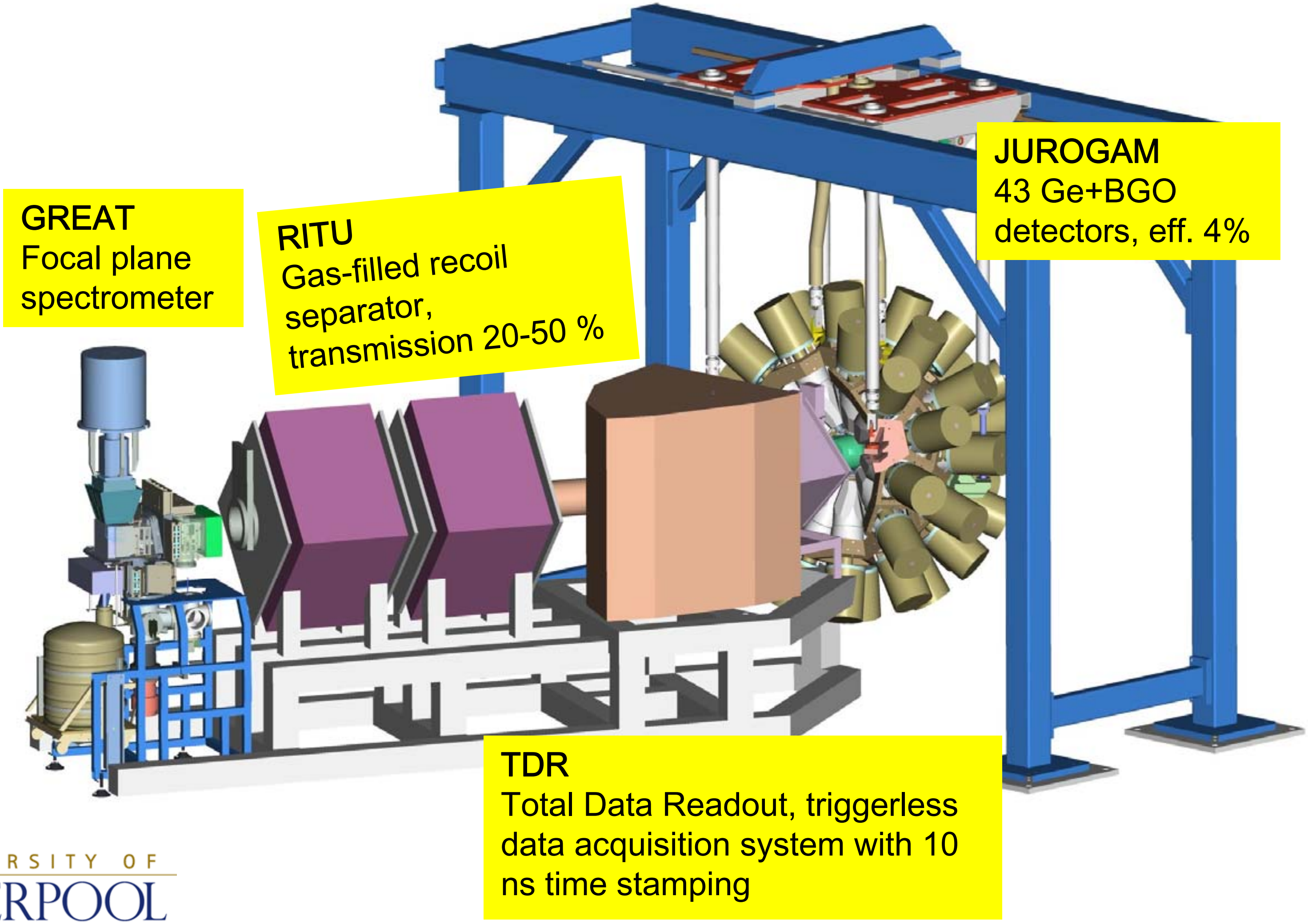
RDT Instrumentation at JYFL



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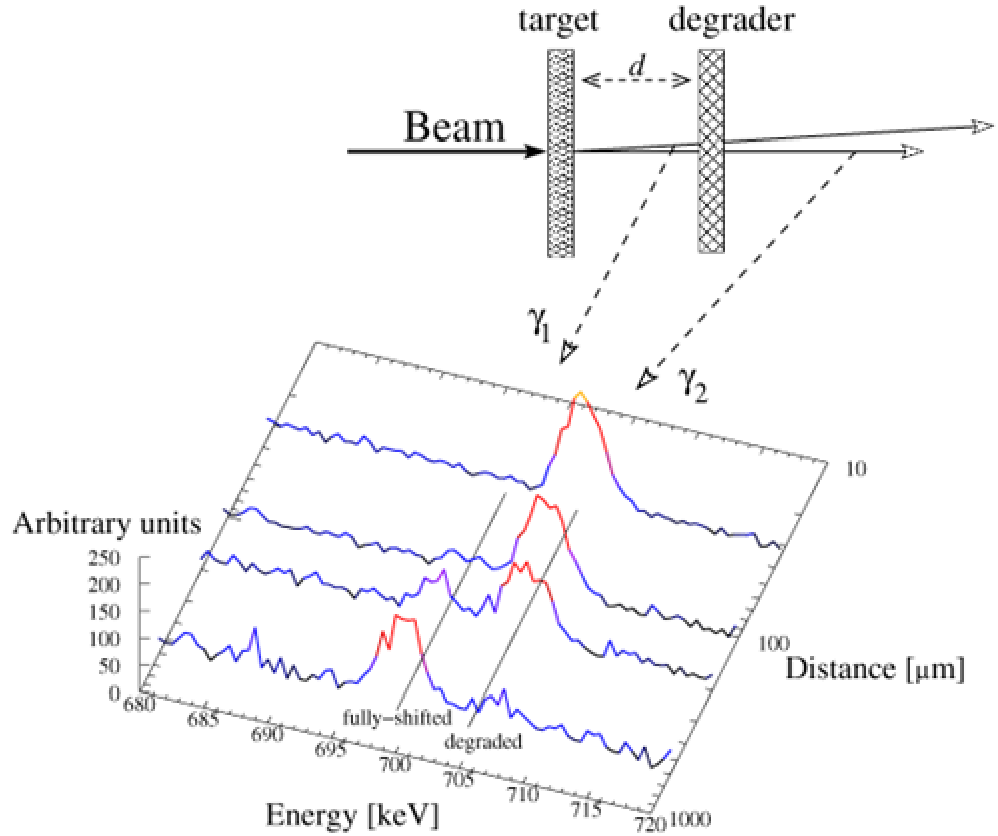
RDDS lifetime measurements at the JYFL



First ever recoil distance Doppler-shift (RDDS) lifetime measurements utilising a gas-filled recoil separator and the recoil decay tagging (RDT) technique → a special plunger device with a degrader foil designed by the University of Köln.

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RDDS lifetime measurements at JYFL

Difficulties

Use of the degrader foil:

- JUROGAM Ge-detector counting rate increases.
- With a 1 mg/cm^2 Mg foil, RITU transmission efficiency cut by a factor of 2/3.
- Doppler-shift difference rather low: v/c = 4% $\rightarrow$ v/c =3%.

Suitable θ:

- Only 15 of JUROGAM Ge-detectors can be used; 5 at 158° and 10 at 134°.
- Ge efficiency reduced significantly.

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BACKGROUND AND MOTIVATION

- In the light Pb region, close to the neutron mid-shell at $N = 104$, quadrupole collectivity and shape coexistence have been extensively studied experimentally and theoretically.
- However, the knowledge of transition probabilities is usually missing. Those would be an absolute measure of collectivity and could shed light on configuration mixing.

  → Couple the Köln plunger device to JUROGAM + RITU at the University of Jyväskylä (JYFL).
- ^{186}Pb & ^{194}Po: First RDDS lifetime measurements employing the RDT technique. Improved lifetime information on ^{188}Pb using the recoil-gating method (PRL 97, 062501 (2006) & NPA 801, 83 (2008)).
- Proved that RDDS lifetime measurements are possible for such exotic species.

  → Ongoing programme to study lifetimes in nuclei far from stability.

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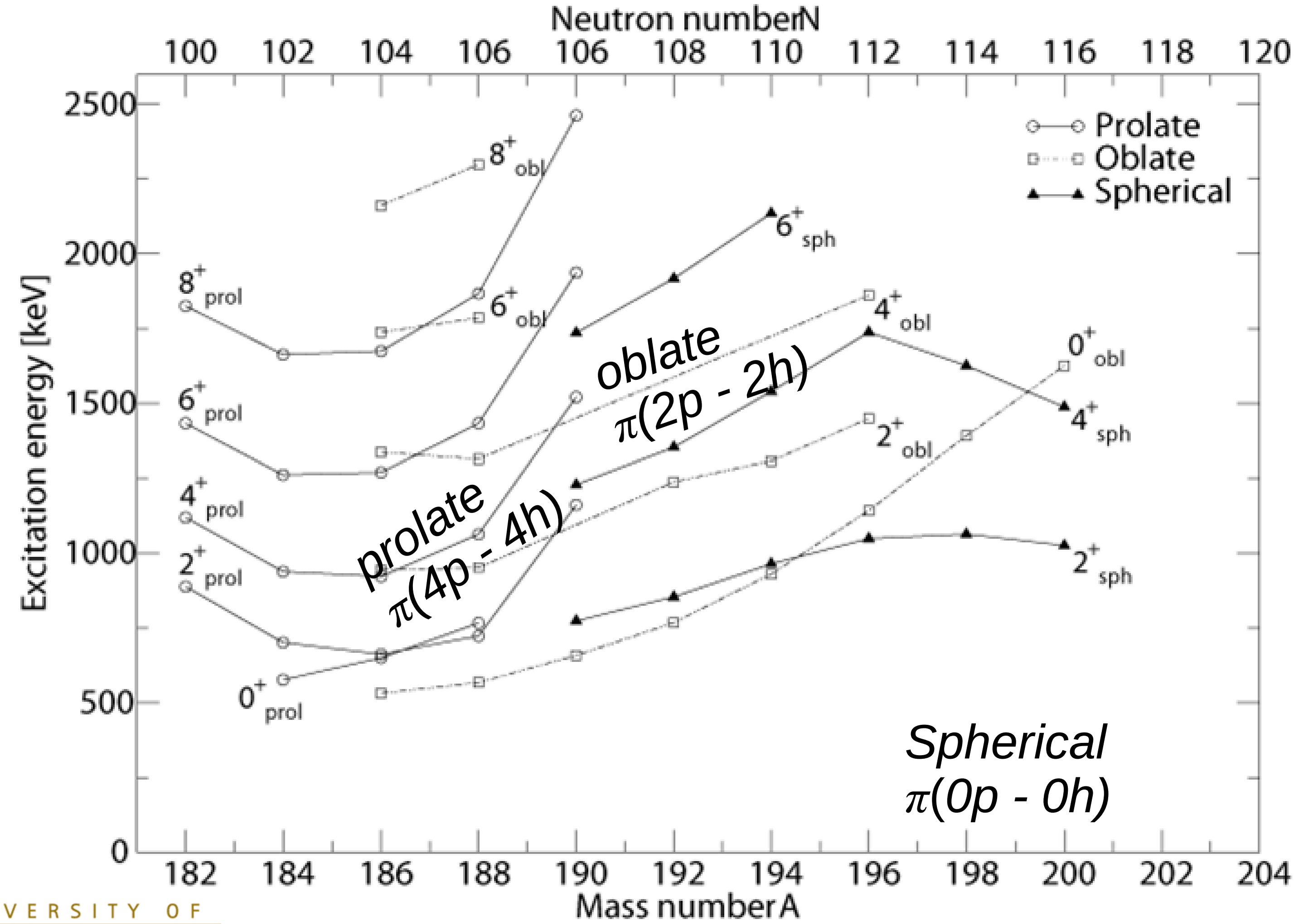
Shape coexistence near Z = 82

An example: Intruder states in neutron-deficient Pb nuclei



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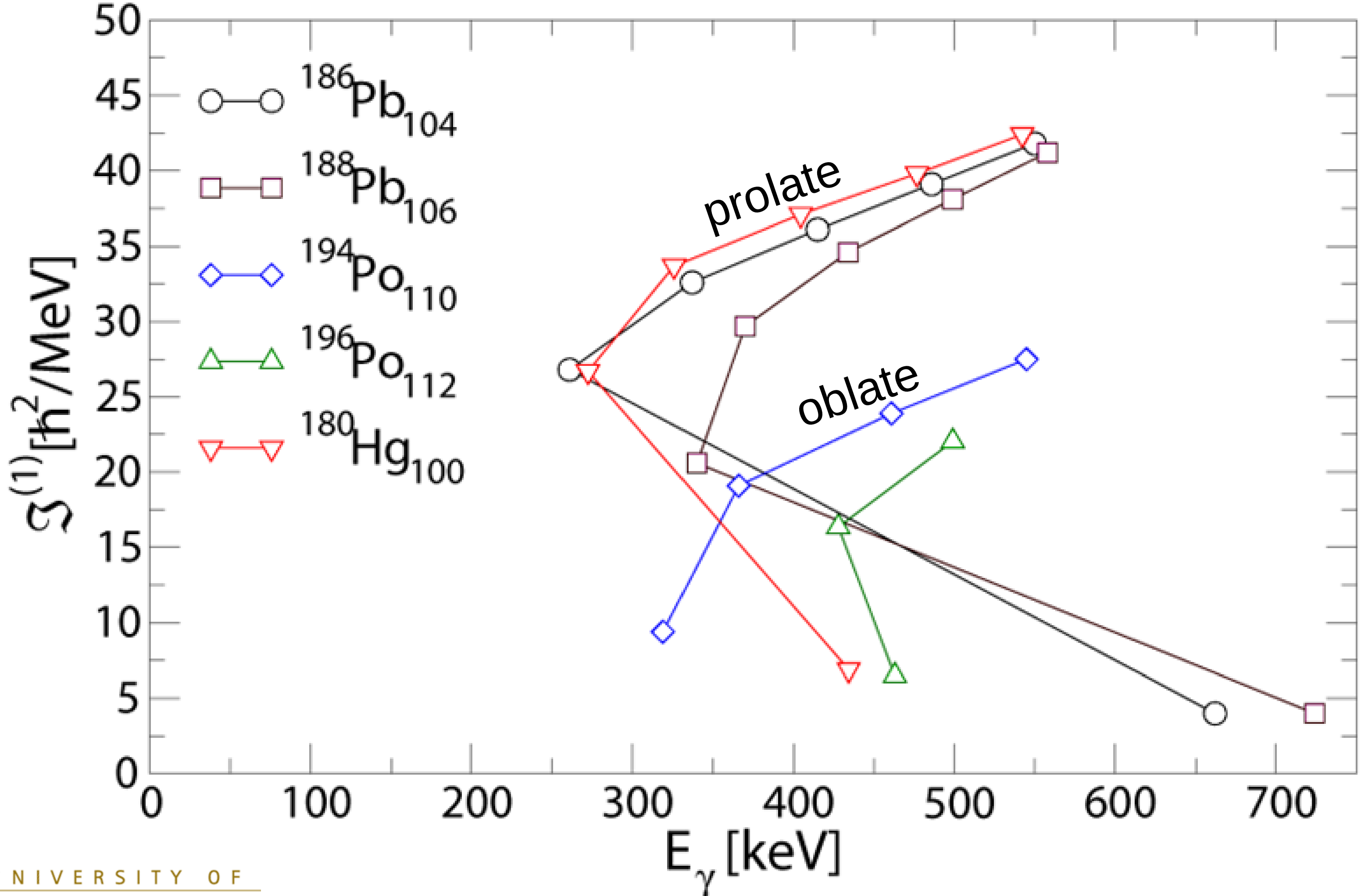
Shape coexistence near *Z* = 82

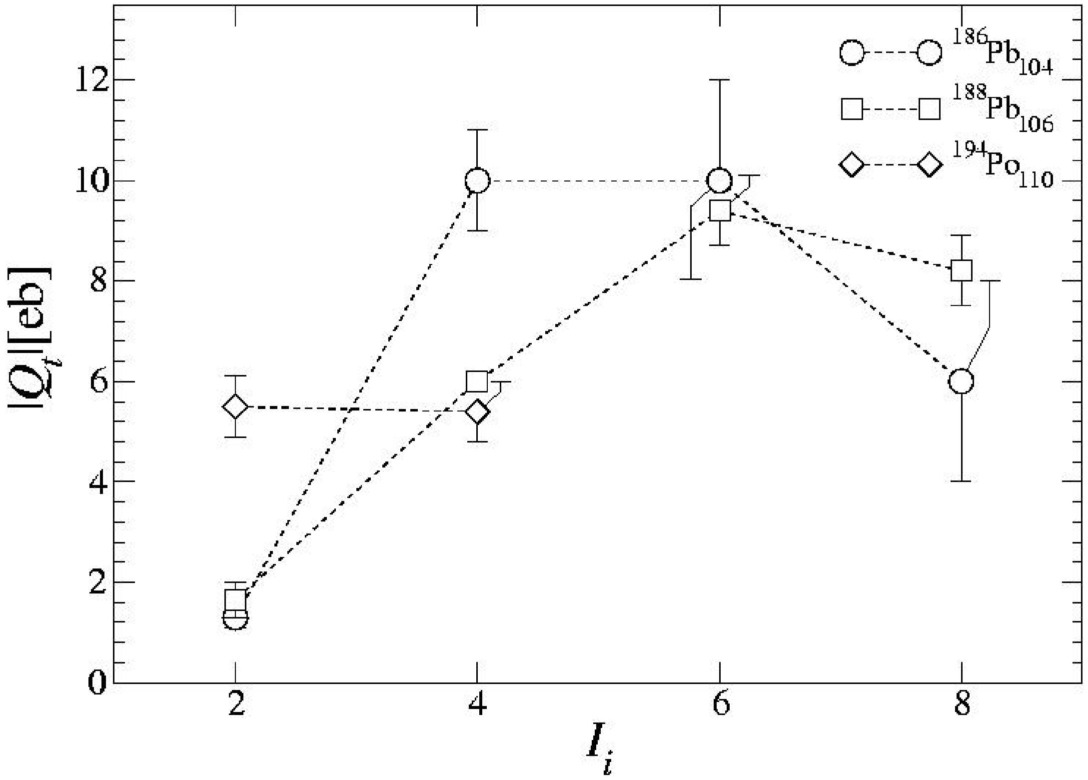
Kinematic moments of inertia



^{186,188}Pb and ^{194}Po

Collectivity and Configuration Mixing

- Verified the collectivity and deformation of prolate and oblate yrast bands in the neutron-deficient Pb region.
- In addition, addressed the question of configuration mixing of the coexisting prolate and oblate shapes.



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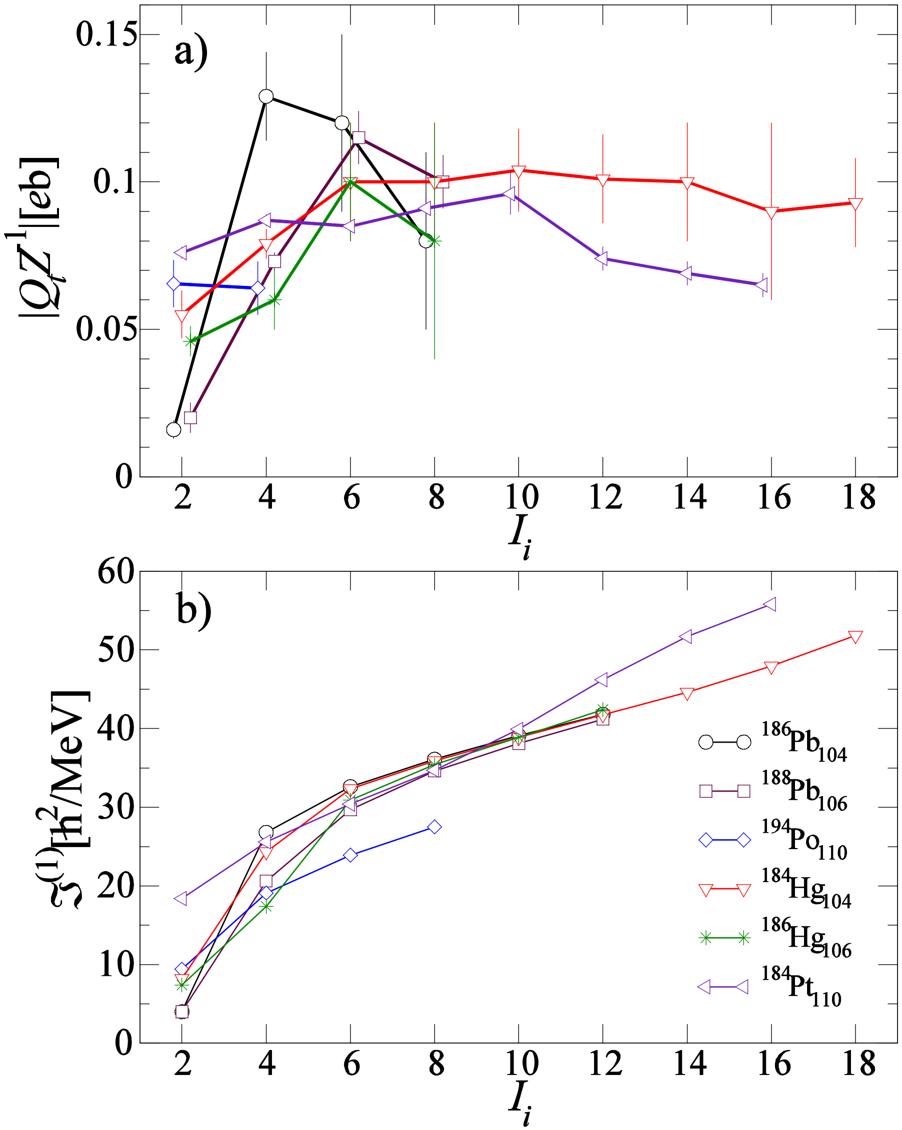
^{186,188}Pb and ^{194}Po

Collectivity and Configuration Mixing

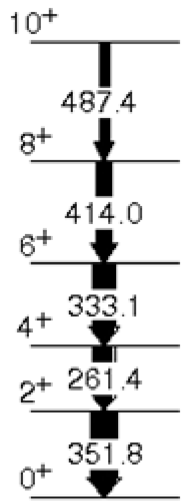
- Verified the collectivity and deformation of prolate and oblate yrast bands in the neutron-deficient Pb region.
- In addition, addressed the question of configuration mixing of the coexisting prolate and oblate shapes.
- Results could indicate the increase of collectivity with increasing proton number → more data needed!

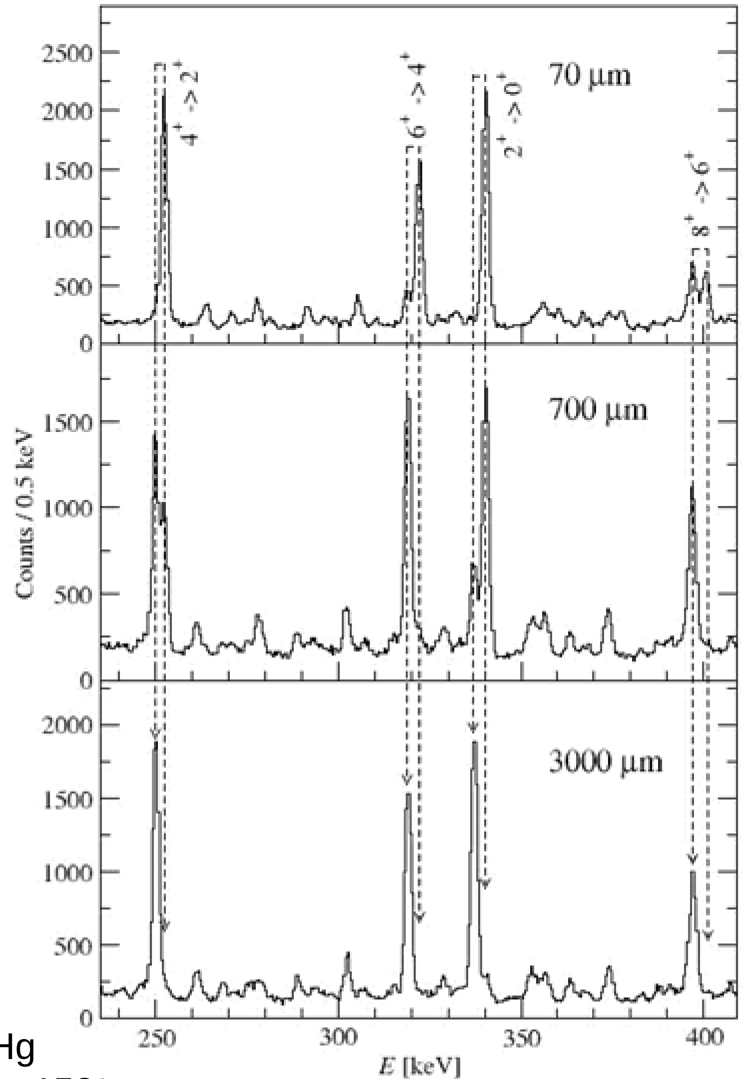


Lifetimes in ^{180,182}Hg

$^{94(96)}$Mo(^{88}Sr,2n)$^{180(182)}$Hg @ 378(371) MeV

- RDDS lifetime measurements of yrast states in ^{180,182}Hg, data analysis completed (T. Grahn, A. Petts, University of Liverpool)
- Will provide systematically data of the collective behaviour and shape coexistence
- Complementary measurements: Coulomb excitation studies of ^{180,182,184,186,188}Hg at REX-ISOLDE (presentation by N. Bree on Friday)





Recoil gated γ γ projection of ^{182}Hg recorded with five Ge detectors at 158°.

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Lifetimes in ^{180,182}Hg

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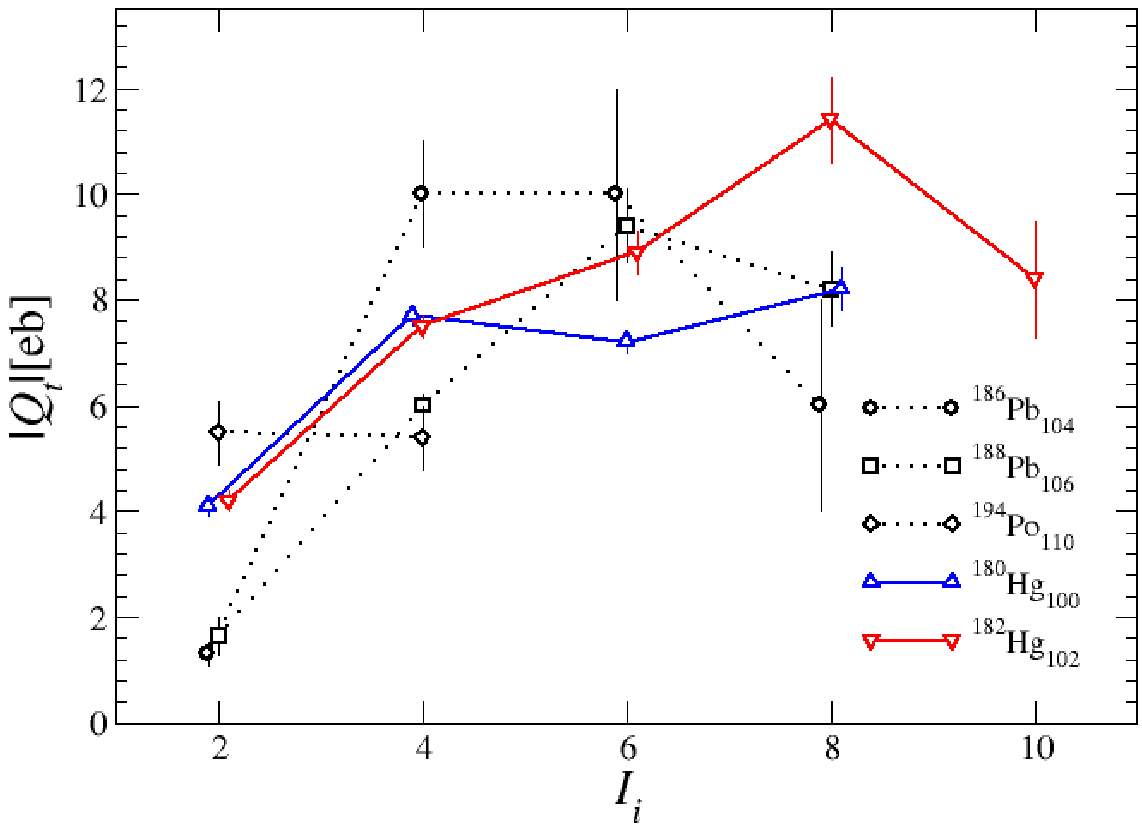

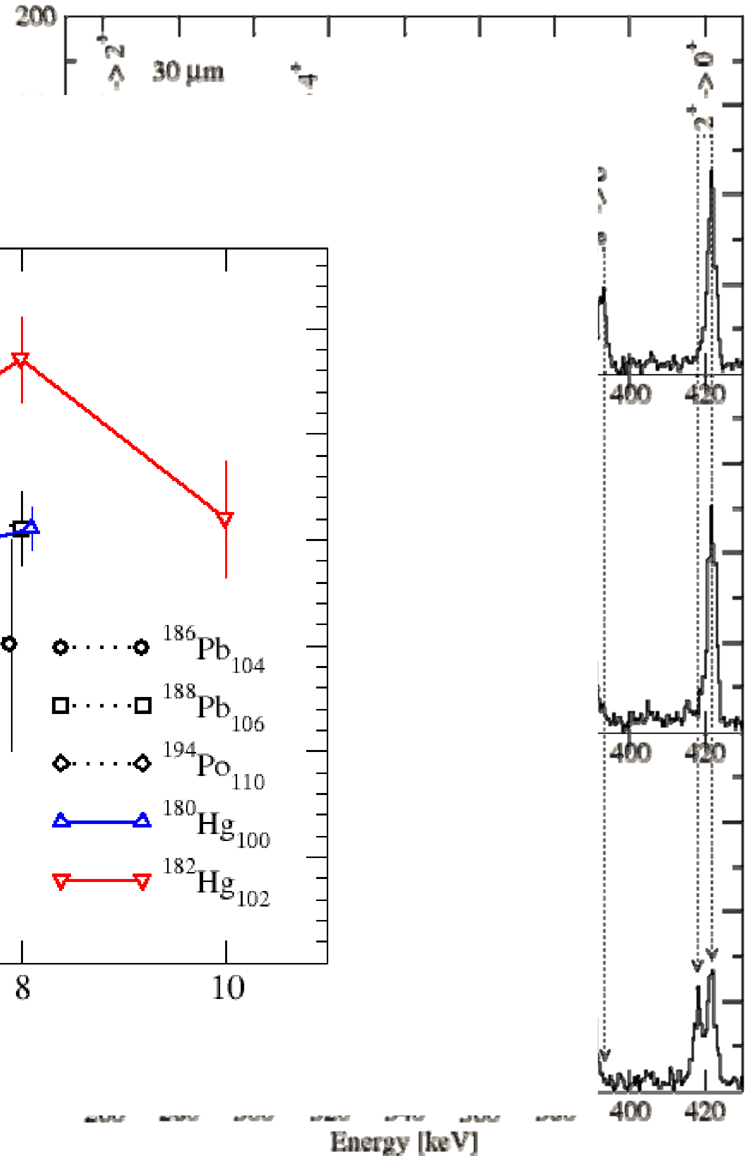

RDT singles γ-ray spectra of ^{180}Hg recorded with five Ge detectors at 158°.

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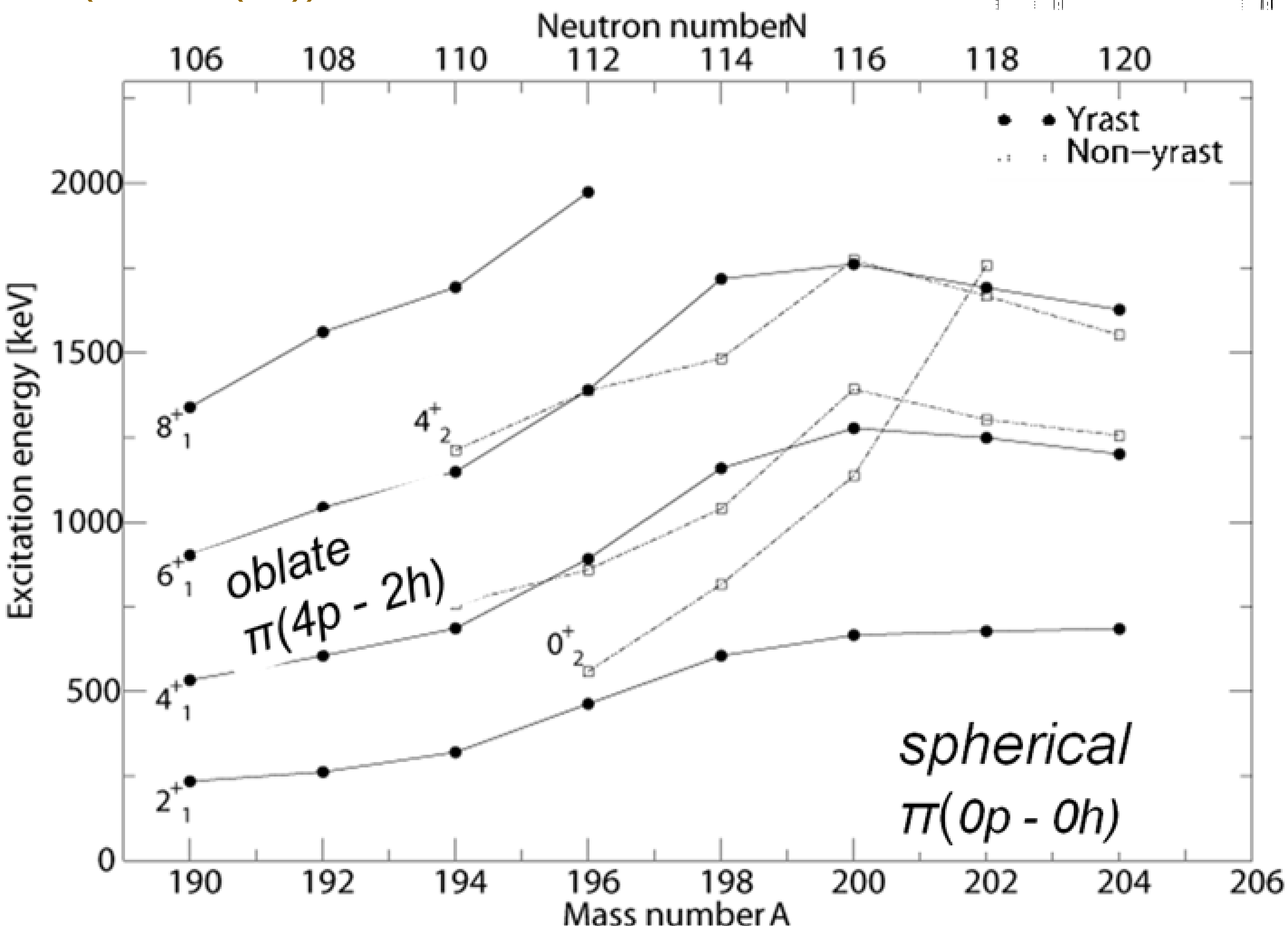
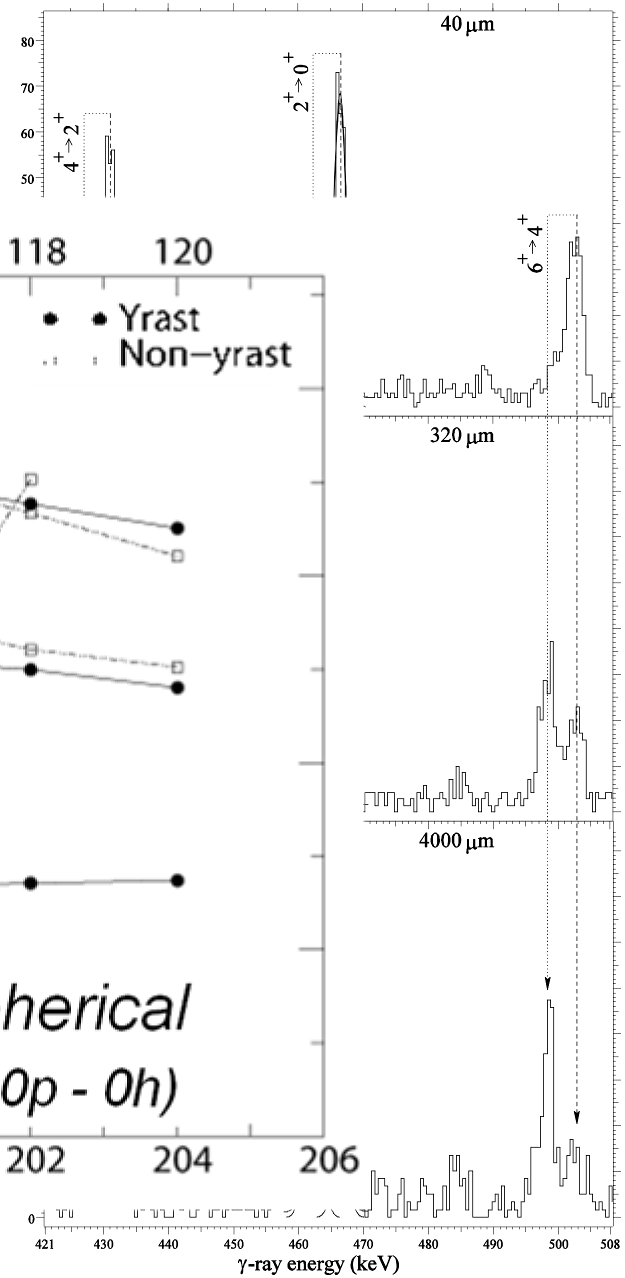
Lifetimes in $^{195,196}Po$

$^{113}Cd(^{86}Kr,3n(4n))^{196(195)}Po$ @ 382 MeV





RDT singles γ-ray spectra of ^{196}Po recorded with five Ge detectors at 158°.

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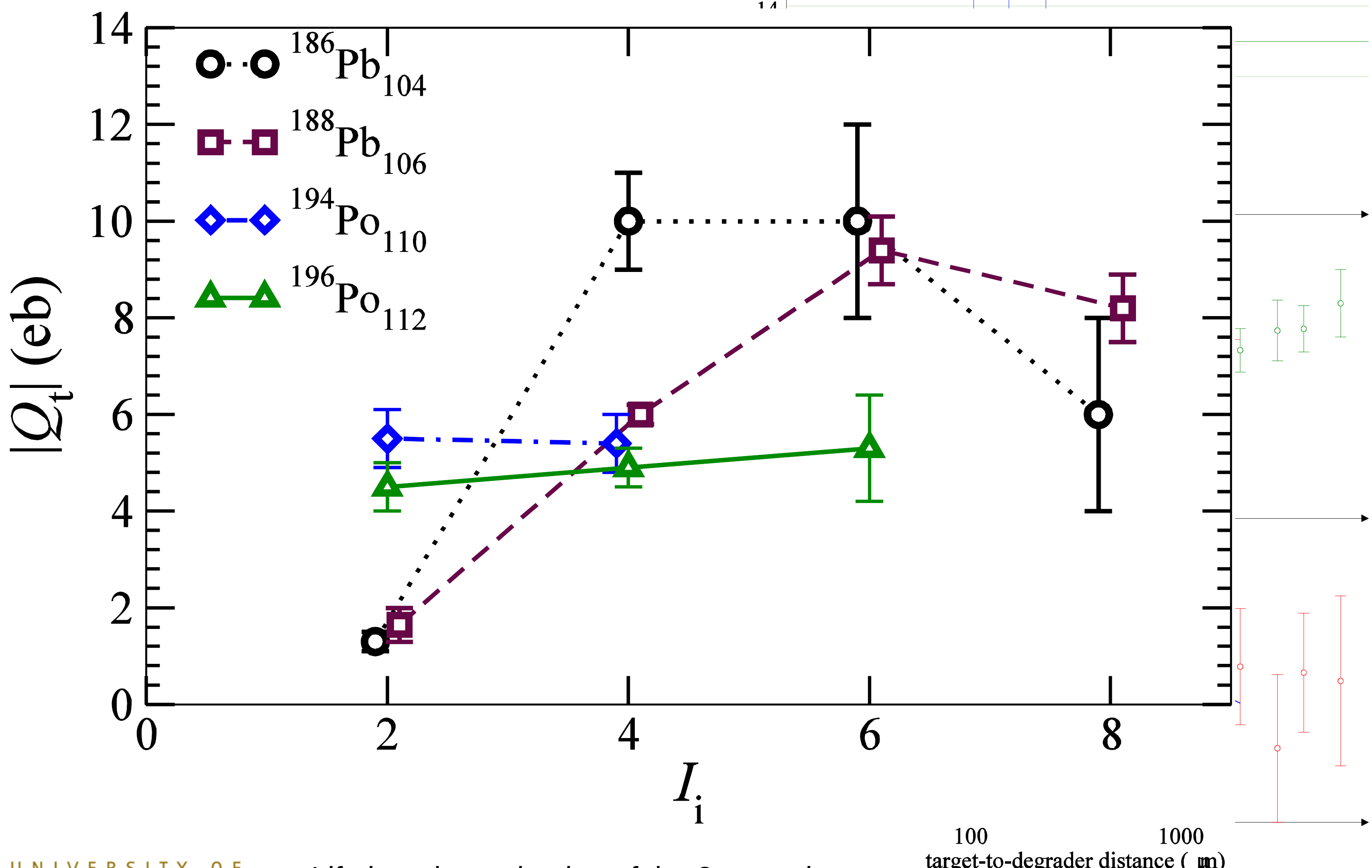
Lifetimes in ^{195,196}Po



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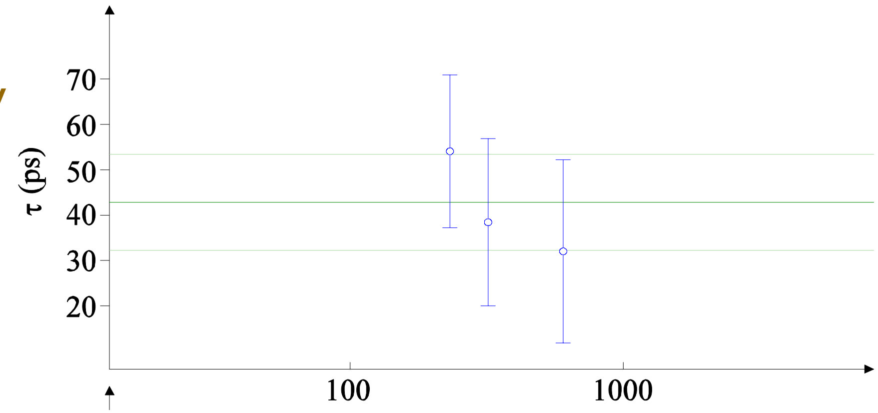
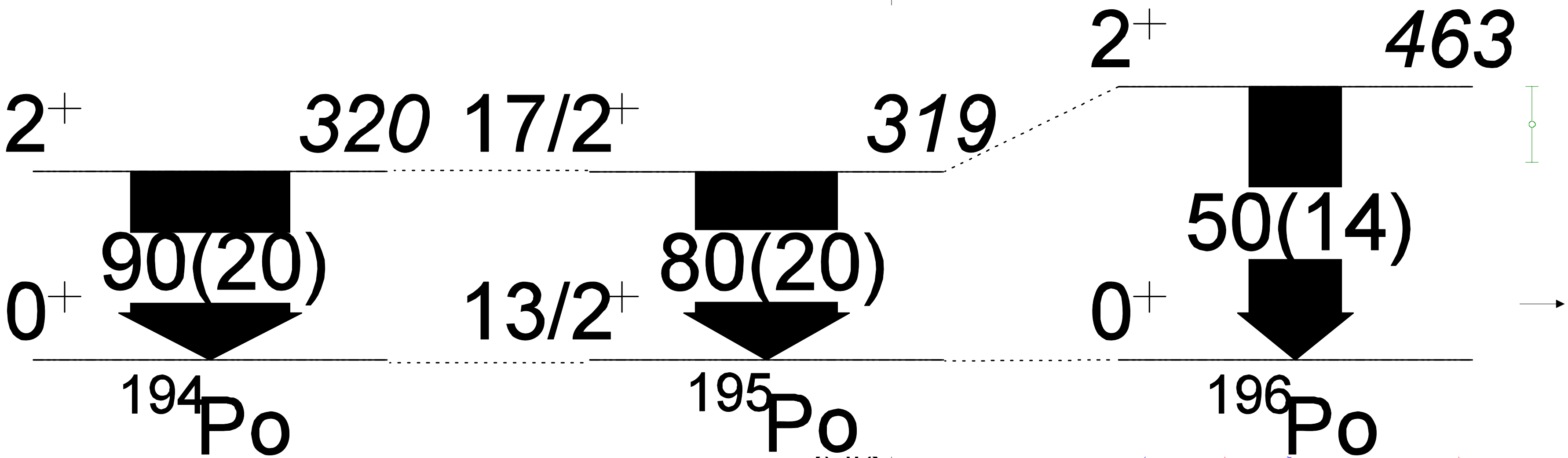
Lifetime determination of the 2^+ state in ^{196}Po. The decay curve is recorded with five Ge detectors at 158°.

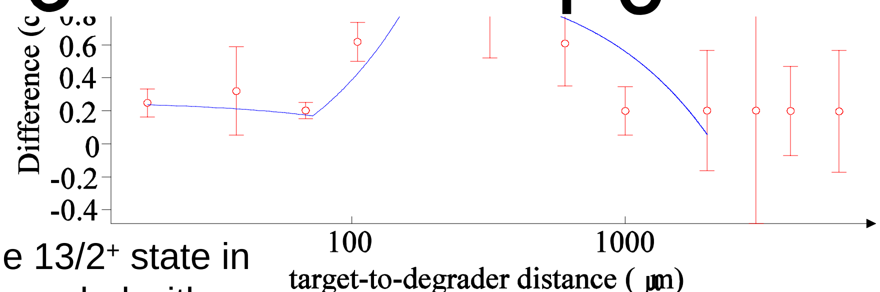
Lifetimes in ^{195,196}Po

^{113}Cd(^{86}Kr,3n(4n))$^{196(195)}$Po @ 382 MeV

- ^{195}Po was produced rather strongly.
- Lifetime of the 17/2^{+} state extracted.







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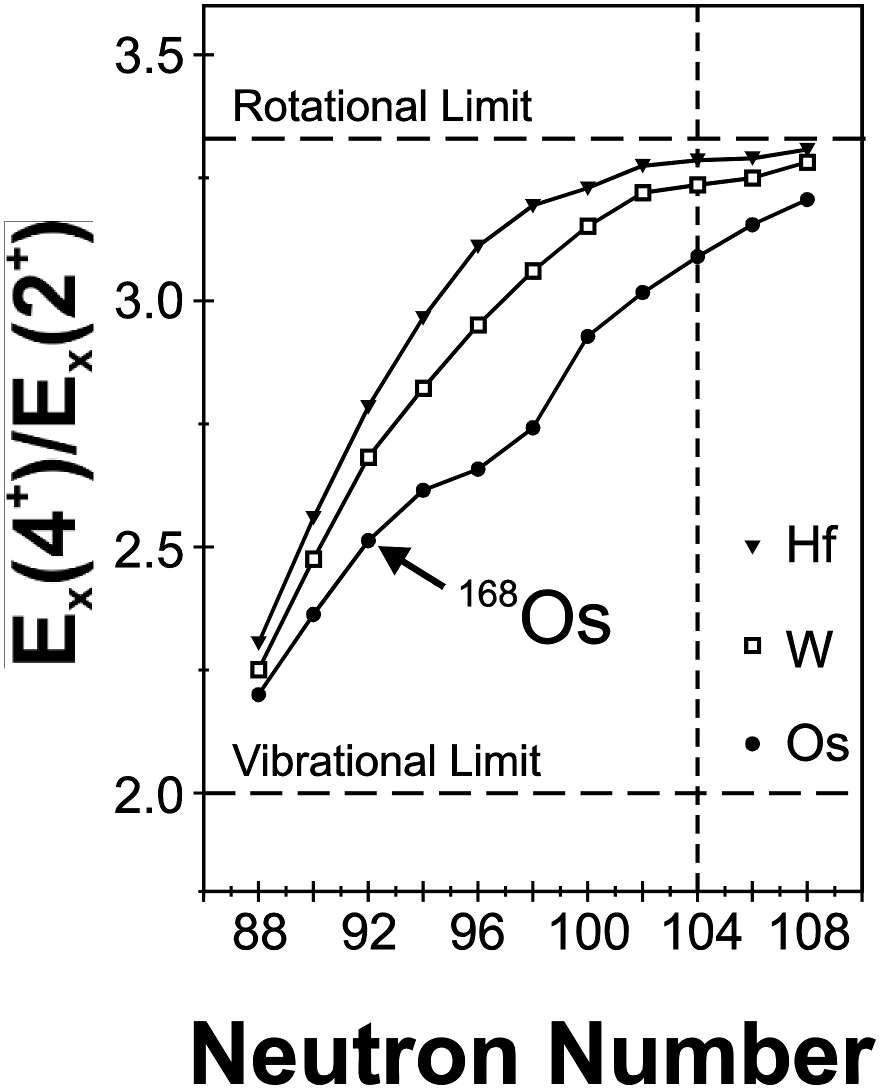
Lifetime determination of the 13/2^{+} state in ^{195}Po. The decay curve is recorded with five Ge detectors at 158°.

Lifetime measurements of $^{167,168}Os$

$^{92}Mo(^{78}Kr,2p(2pn))^{168(167)}Os$ @ 336 MeV

- ^{168}Os has *E(4+)/E(2+)* = 2.51 → very close to the value of a gamma-soft rotor.
- The *E(4+)/E(2+)* ratio of the light Os isotopes evolves from deformed rotors towards the vibrational limit, when the *N=82* shell gap is approached.
- No quantitative measurements of deformation and *B(E2)* values (yet).



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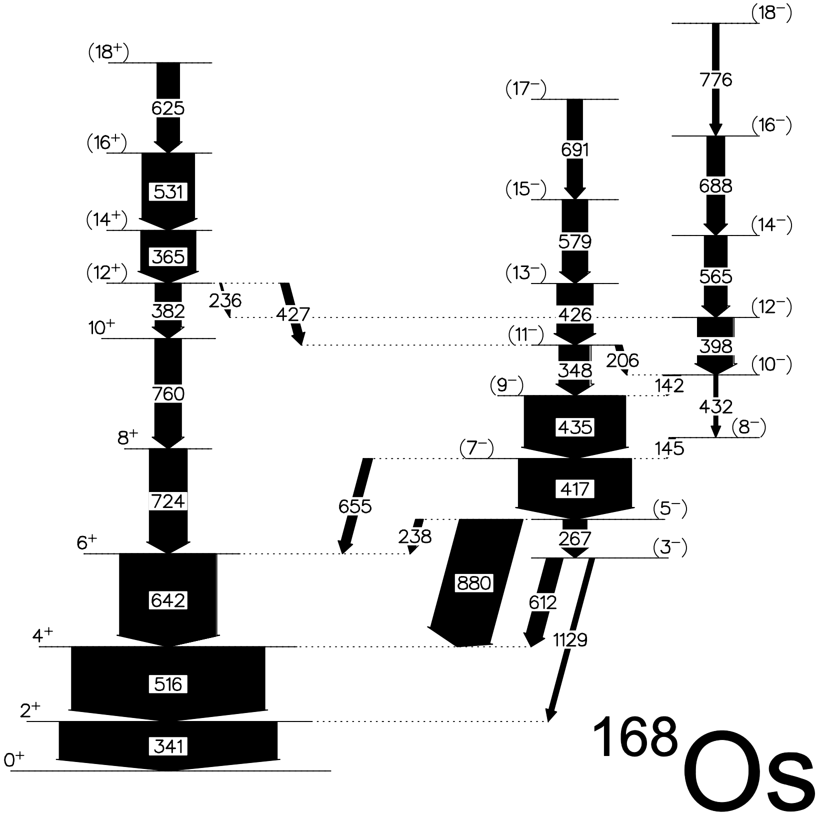
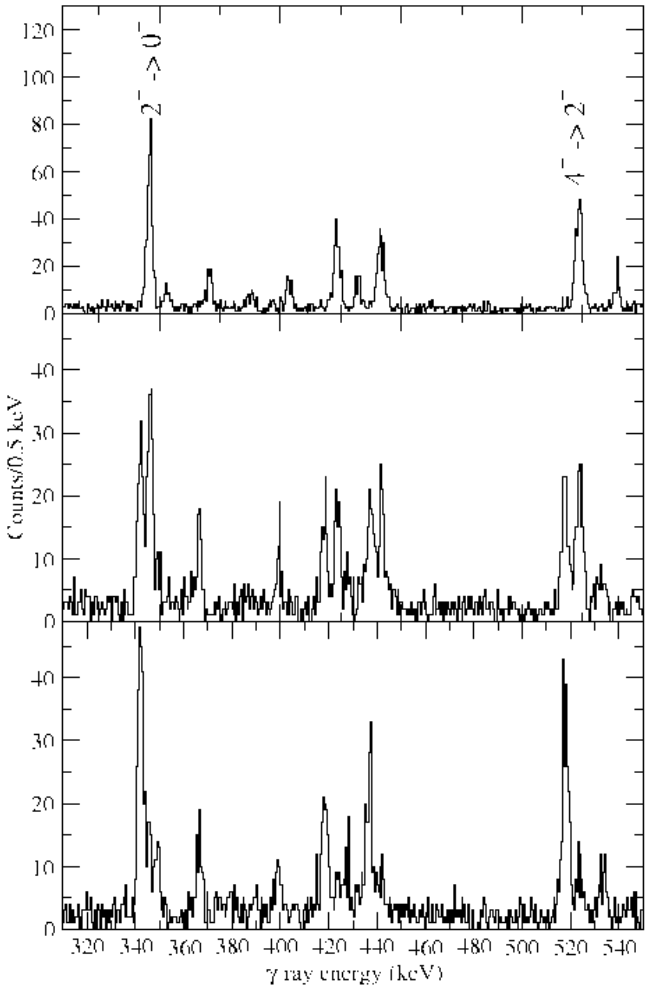
Lifetime measurements of $^{167,168}Os$

$^{92}Mo(^{78}Kr,2p(2pn))^{168(167)}Os$ @ 336 MeV





RDT singles γ-ray spectra of ^{166}Os recorded with five Ge detectors at 158°.

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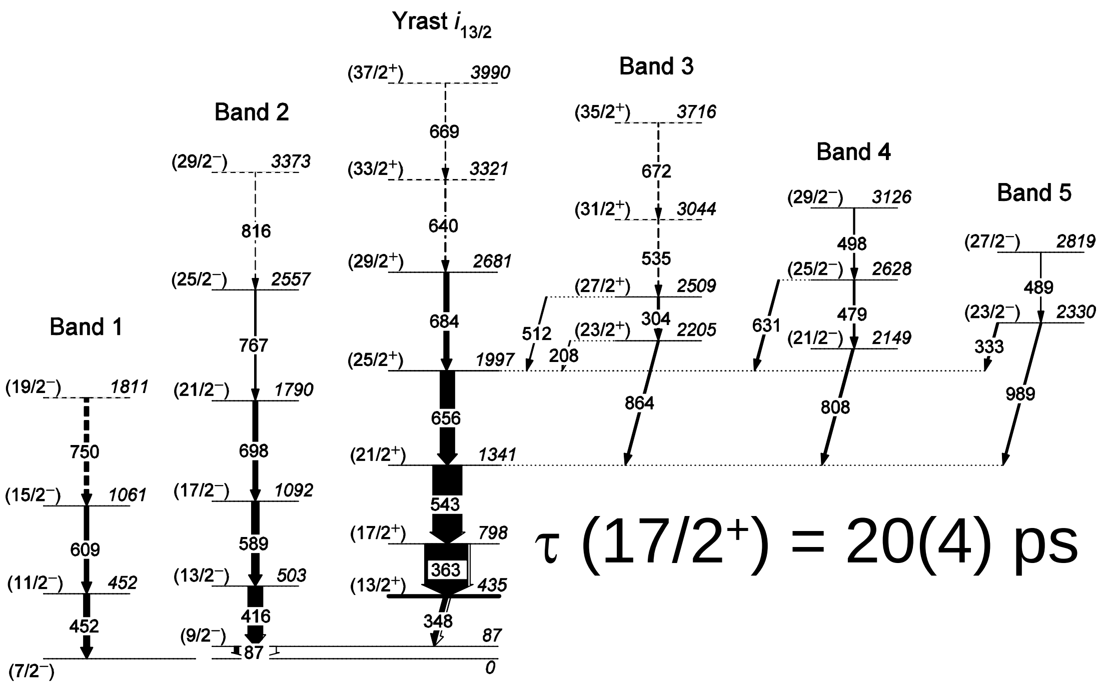
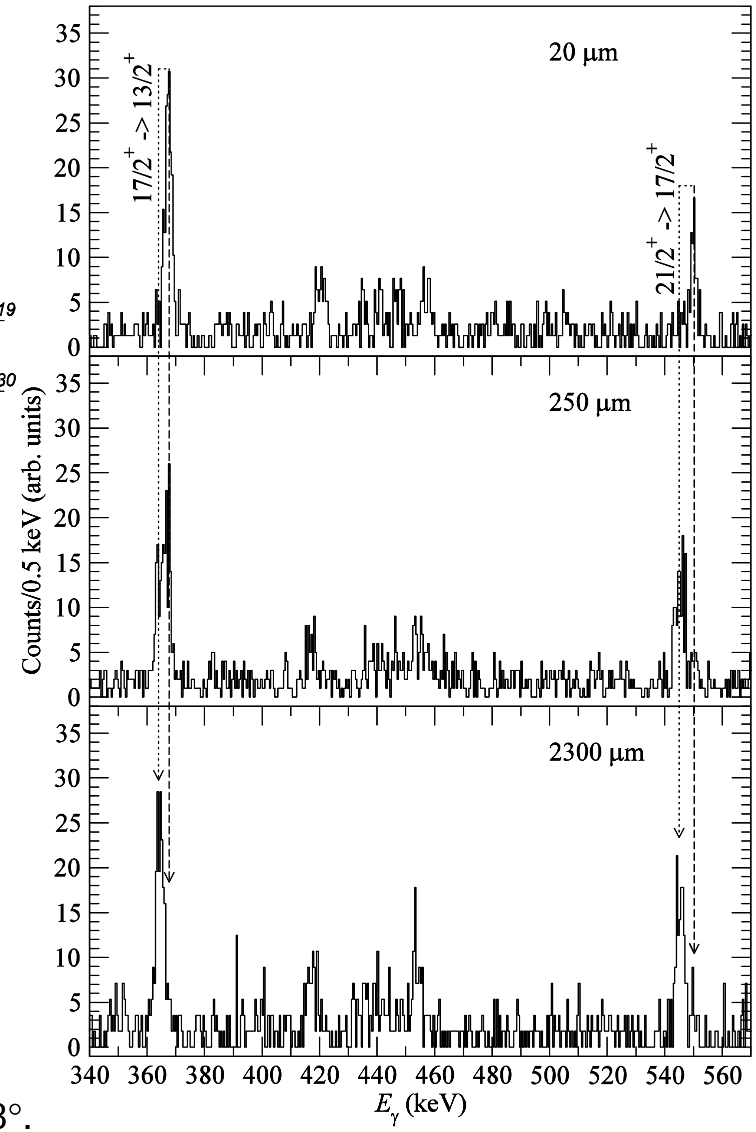
Lifetime measurements of $^{167,168}Os$

$^{92}Mo(^{78}Kr,2p(2pn))^{168(167)}Os$ @ 336 MeV



τ (17/2⁺) = 20(4) ps

Level scheme by D. O'Donnell



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RDT singles γ-ray spectra of ^{167}Os recorded with five Ge detectors at 158°.

FUTURE PROSPECTS

- RDDS measurements in the light Pb region are strongly connected to the Coulomb excitation measurements carried out at REX-ISOLDE.

  $\rightarrow$ Level lifetimes needed in Coulex analysis in order to extract the sign of quadrupole moment.
- Approved RDDS measurements at JYFL:

  ^{109}I - The first proton tagged RDDS measurement.

  ^{175}Au - Shape coexistence beyond the neutron midshell.
- JUROGAM II: more Ge efficiency at $\theta \approx 90°$ $\rightarrow$ more $\gamma\gamma$ measurements could be possible.
- New techniques:

  Isomer tagged RDDS measurements (^{144}Ho – Presentation by P. Mason).

  RDDS measurements using Coulomb excitation (^{128,130}Xe – IKP Köln).

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