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Evolution of nuclear shape in the light Radon isotopes

University of York

University of Jyväskylä

Instituut voor Kern- en Stralingsfysica, KU Leuven

CERN

Institut fuer kernphyysik, Universitaet zu Koeln

University of Liverpool

University of Manchester

University of Edinburgh

Technische Universität München

Ludwig-Maximilians-Universita Muenchen

Technische Universität Darmstadt

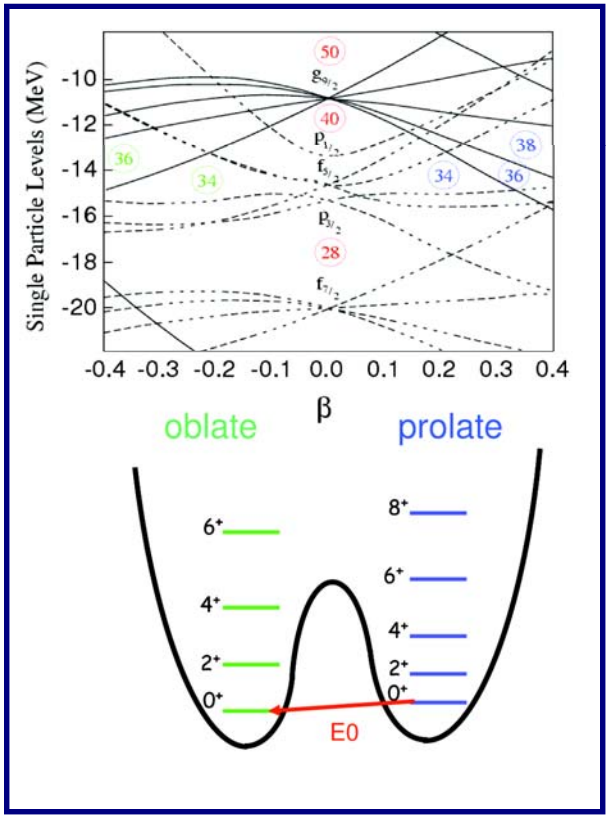
University of Sofia

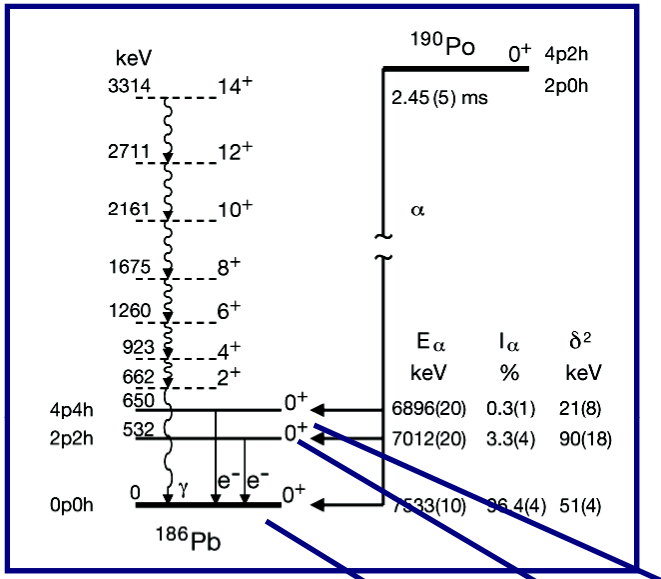
Weizmann Institute of Science

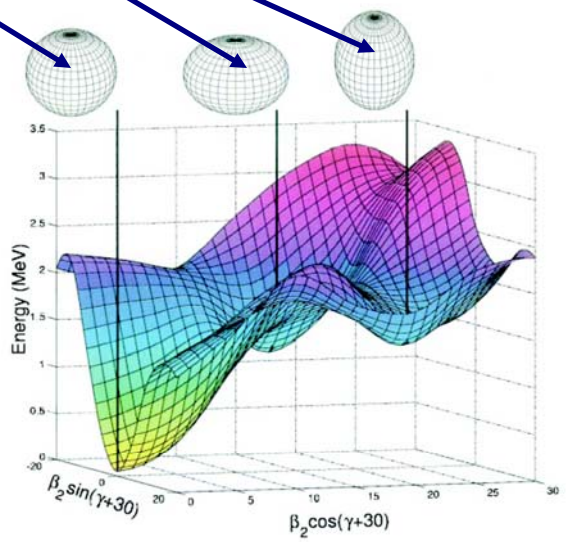
The Miniball Collaboration

Shape Coexistence

Atomic nucleus minimises its energy by adopting different deformed mean-field shapes.







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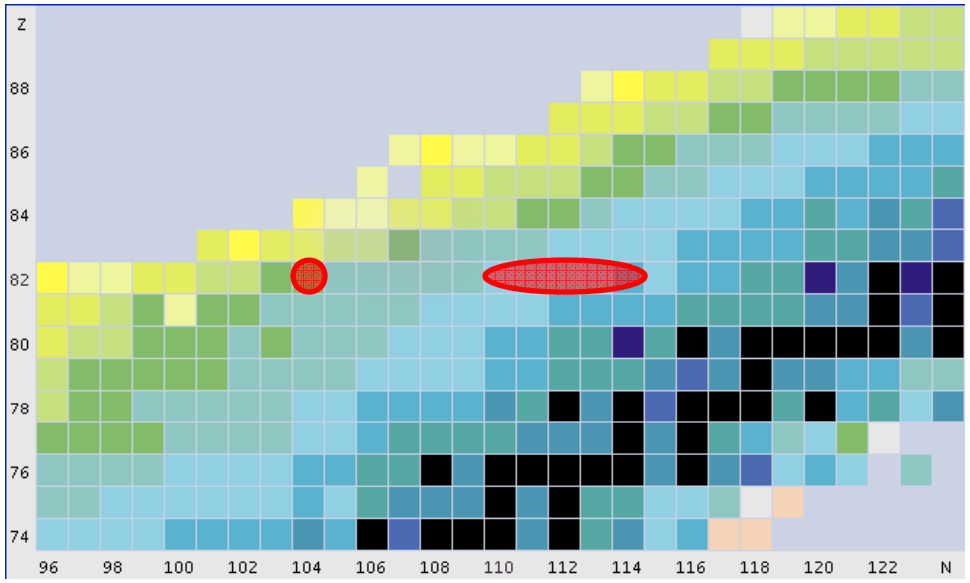
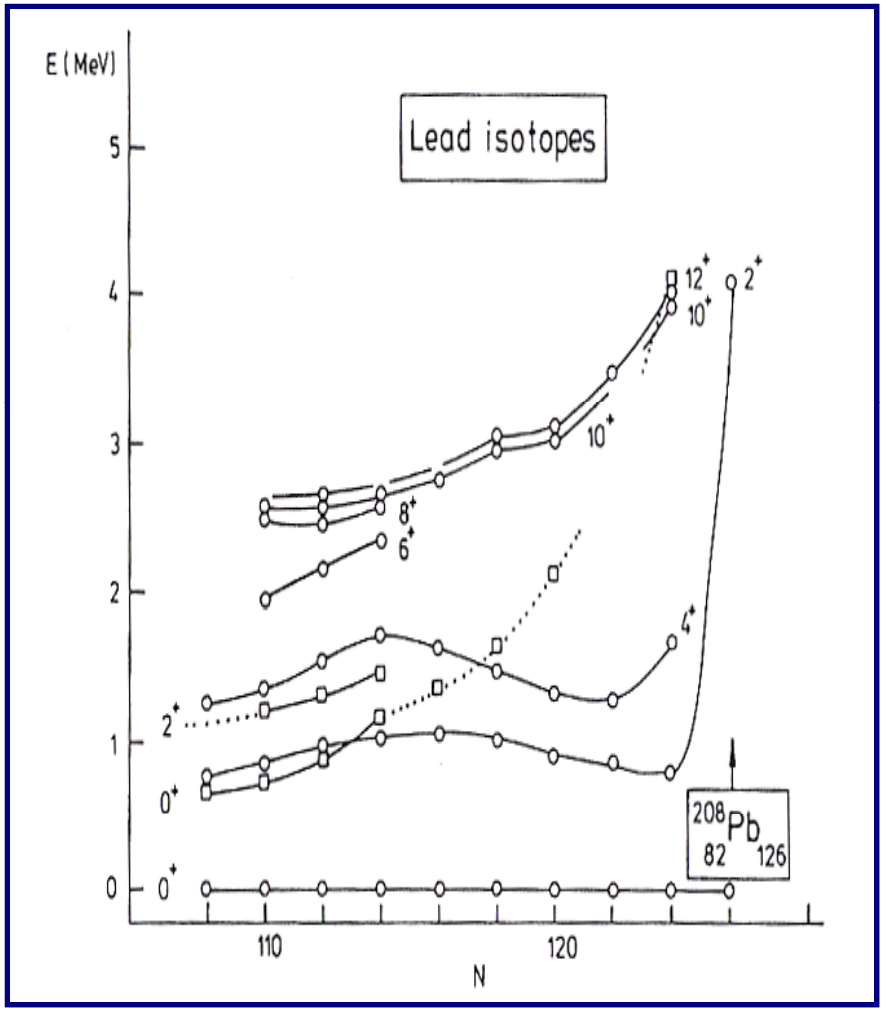
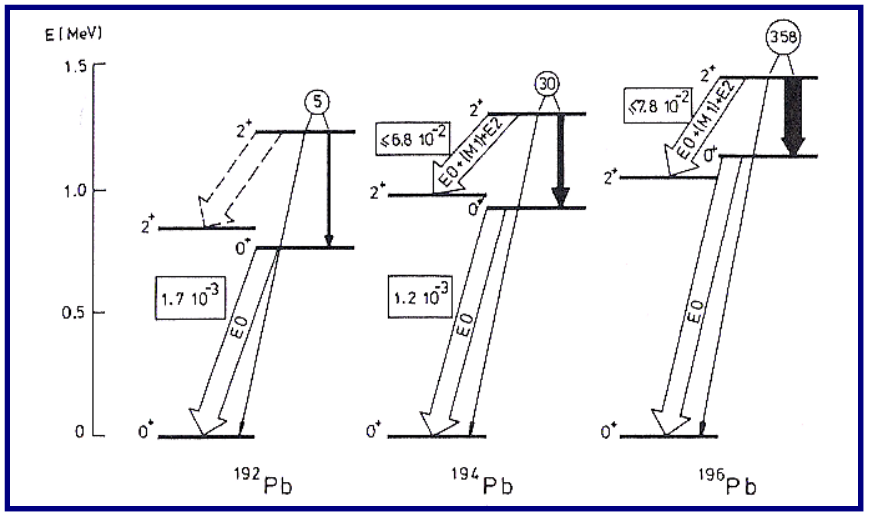
Light Pb isotopes







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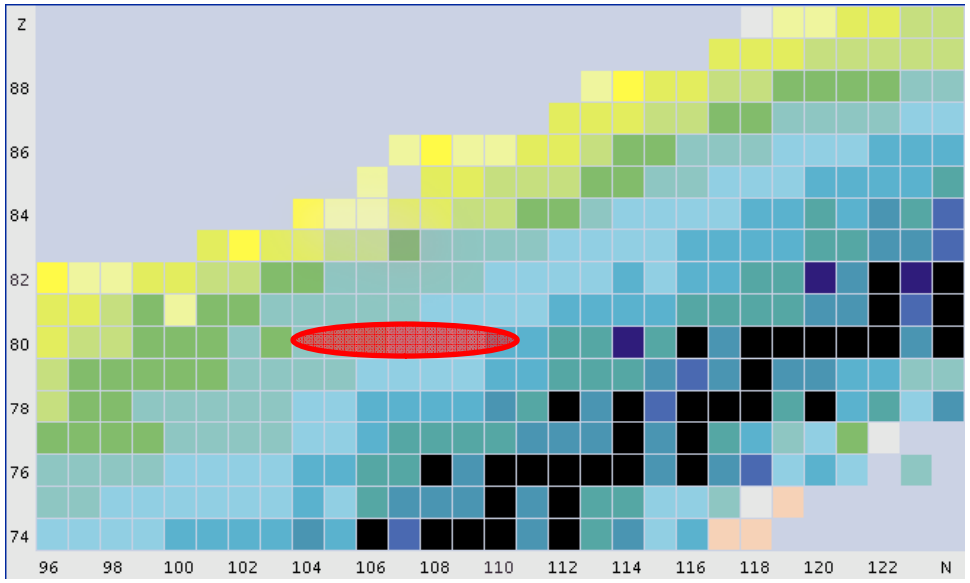
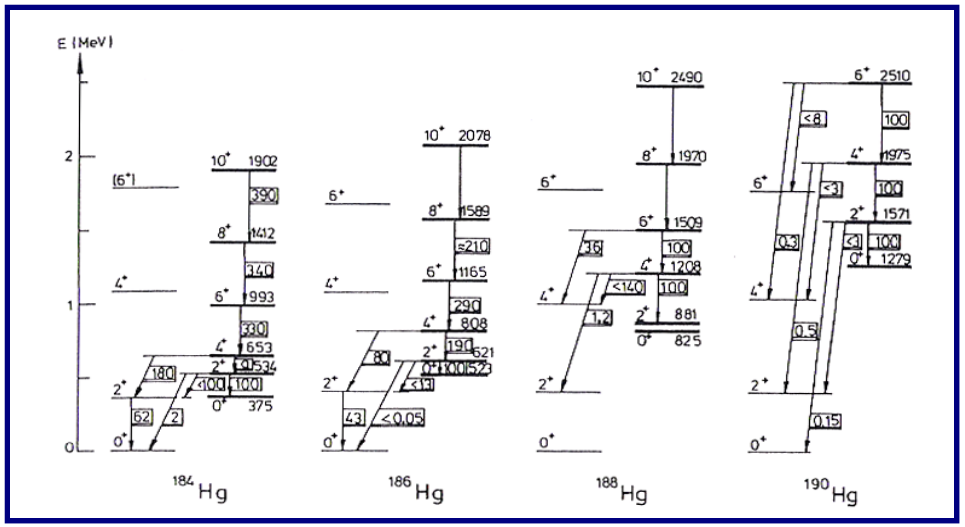
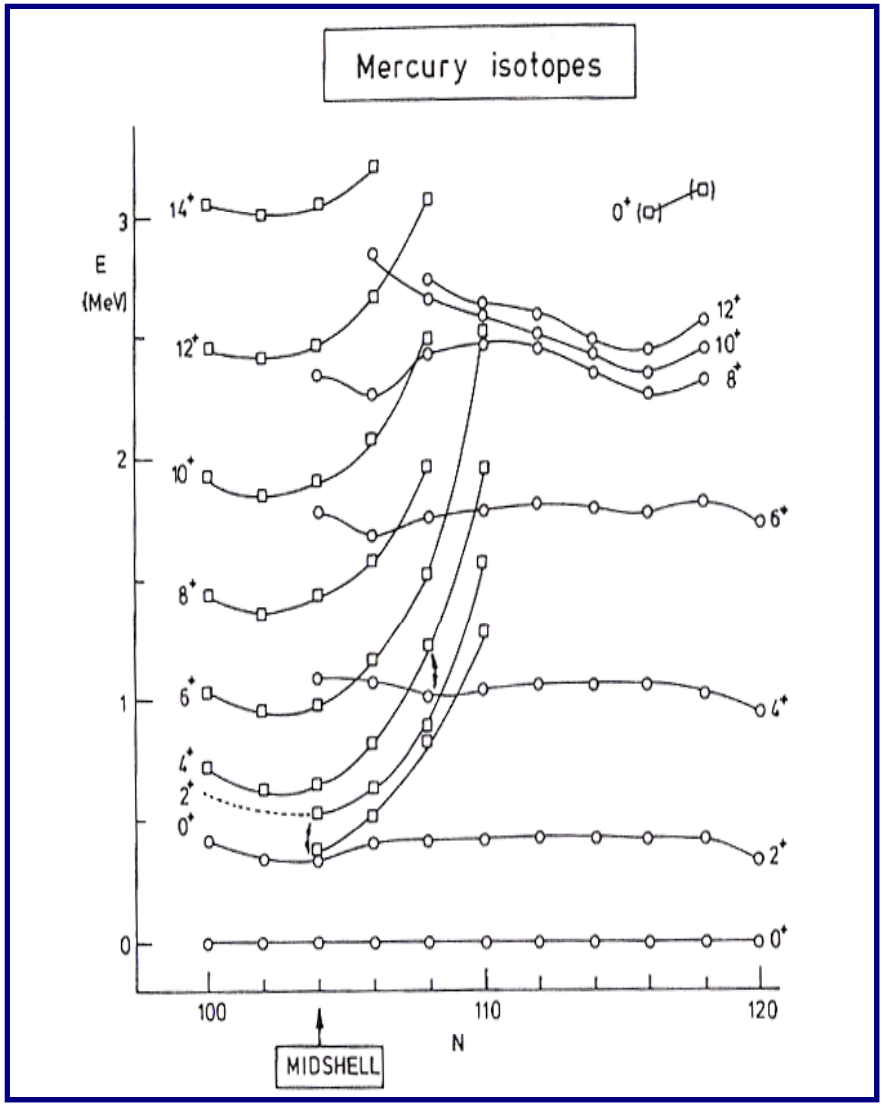
Mercury Isotopes







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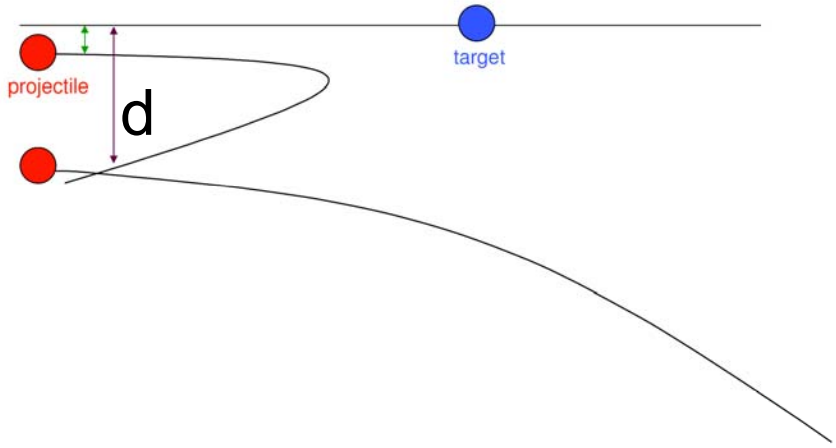
Coulomb Excitation (Coulex)

$$\frac{d\sigma_{CE}}{d\Omega} \propto B(E2, 0_1^+ \rightarrow 2_1^+)$$

$$B(E2, 0_1^+ \rightarrow 2_1^+) \propto \left| \left\langle I_{2^+} \left\| M(E2) \right\| I_{0^+} \right\rangle \right|^2$$

$$\beta_2 \propto \sqrt{B(E2, 0_1^+ \rightarrow 2_1^+)}$$



$$d > 1.25(A_p^{1/3} + A_T^{1/3}) + 5 \text{ [fm]}$$

Coulex with radioactive beams is a highly successful method for establishing the evolution of nuclear shape

^{74,76}Kr at SPIRAL

E. Clement et al., PRC 75, 054313 (2007)

^{70}Se at REX-ISOLDE

A.M. Hurst et al., PRL 98, 072501 (2007)

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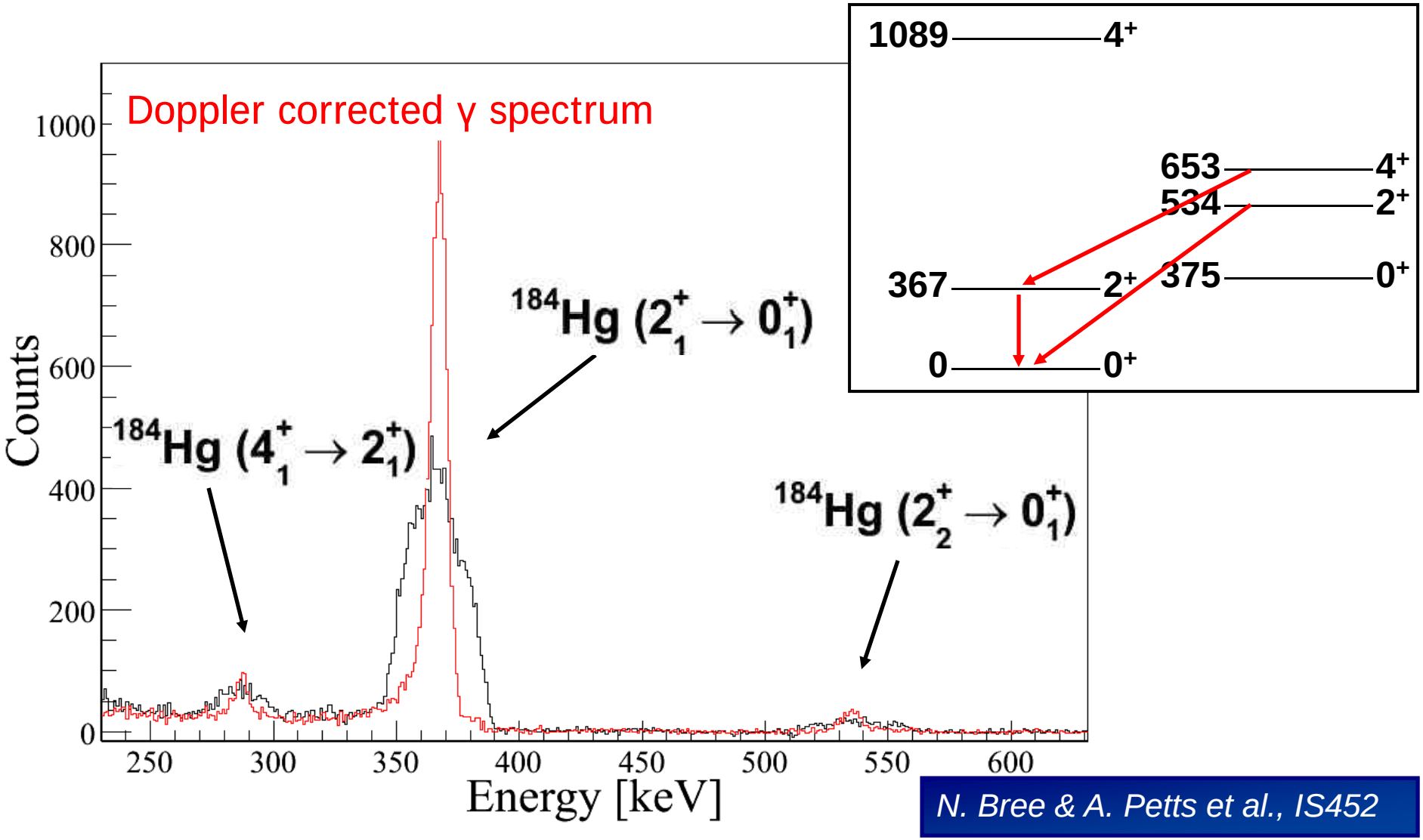
Coulex of Hg Isotopes - IS452



N. Bree & A. Petts et al., IS452

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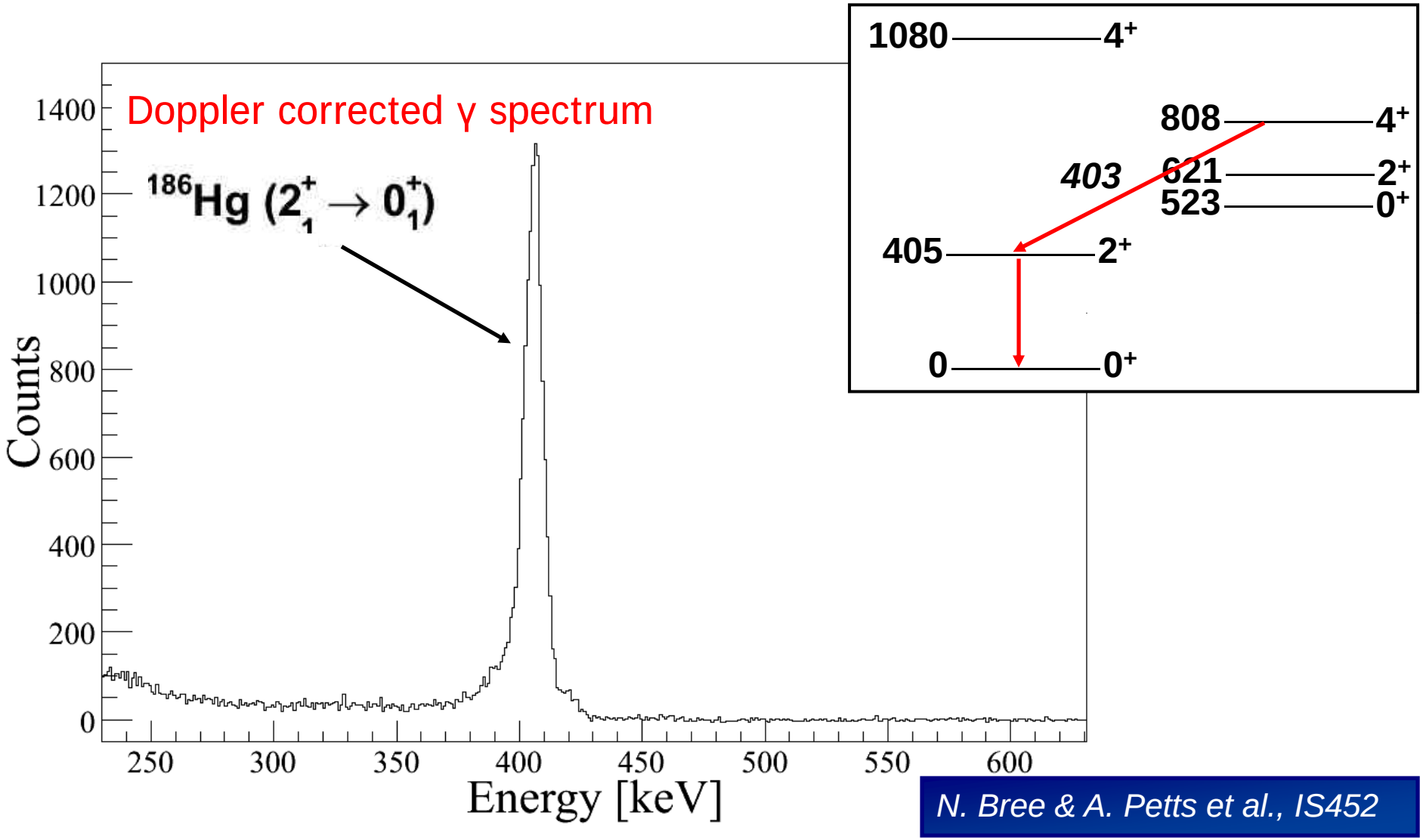
Coulex of Hg Isotopes - IS452



N. Bree & A. Petts et al., IS452

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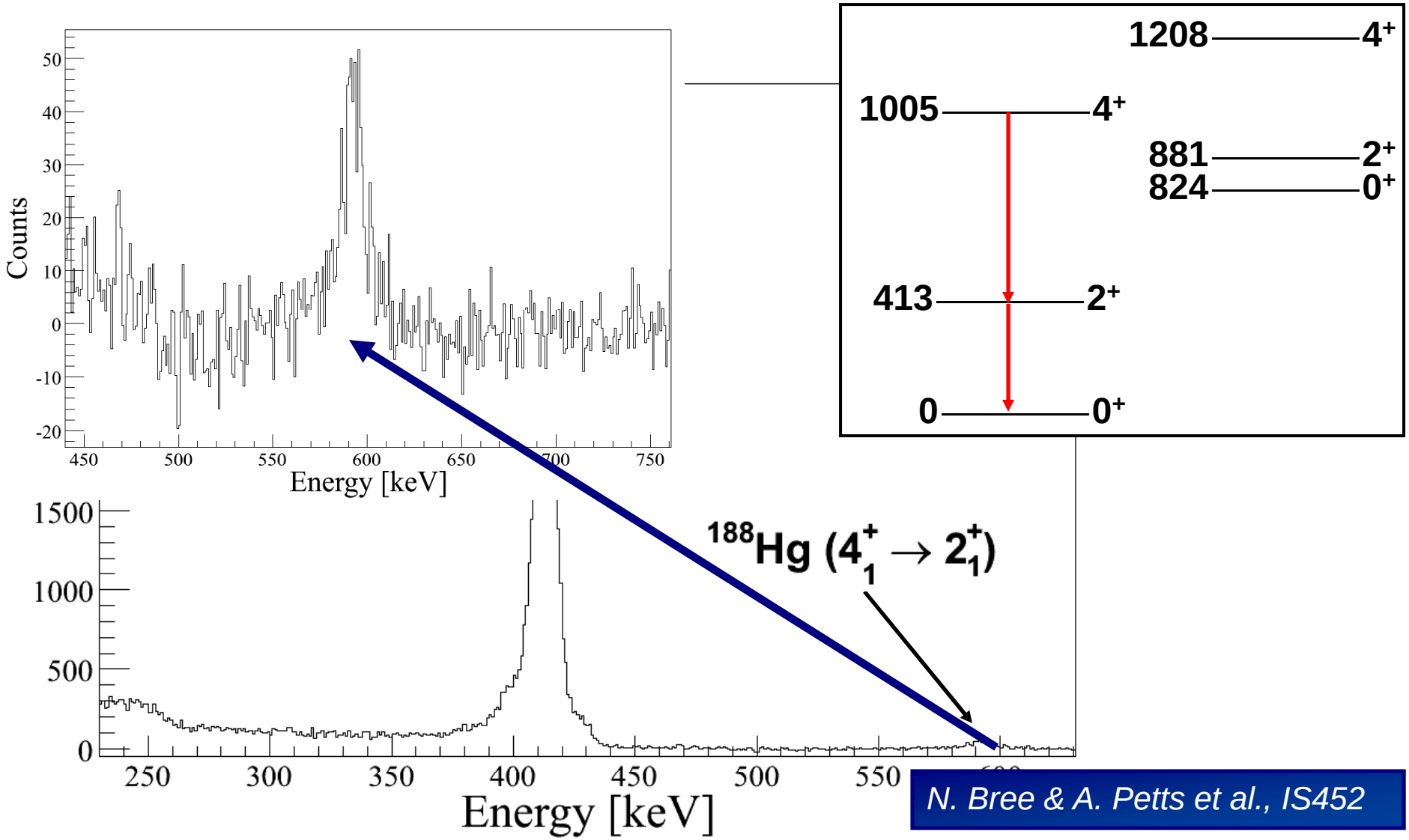

N. Bree & A. Petts et al., IS452

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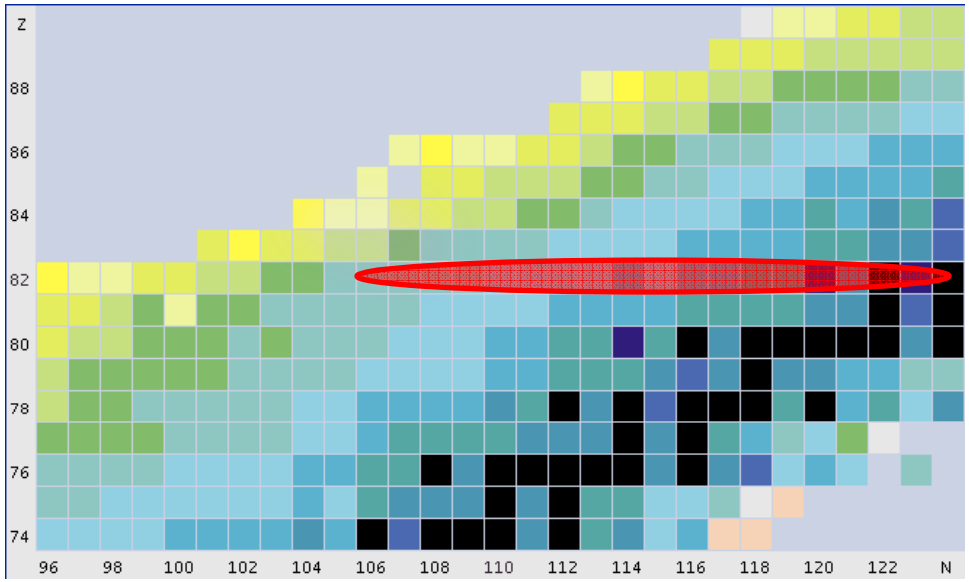
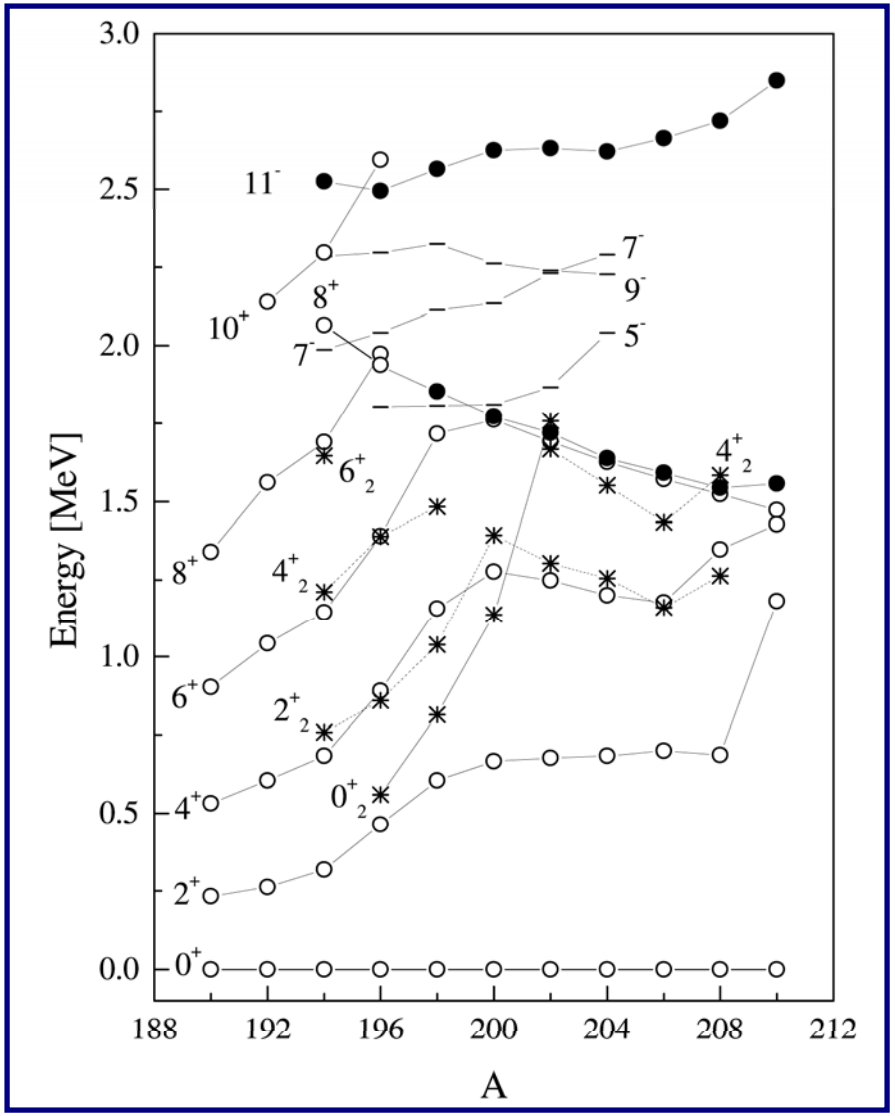
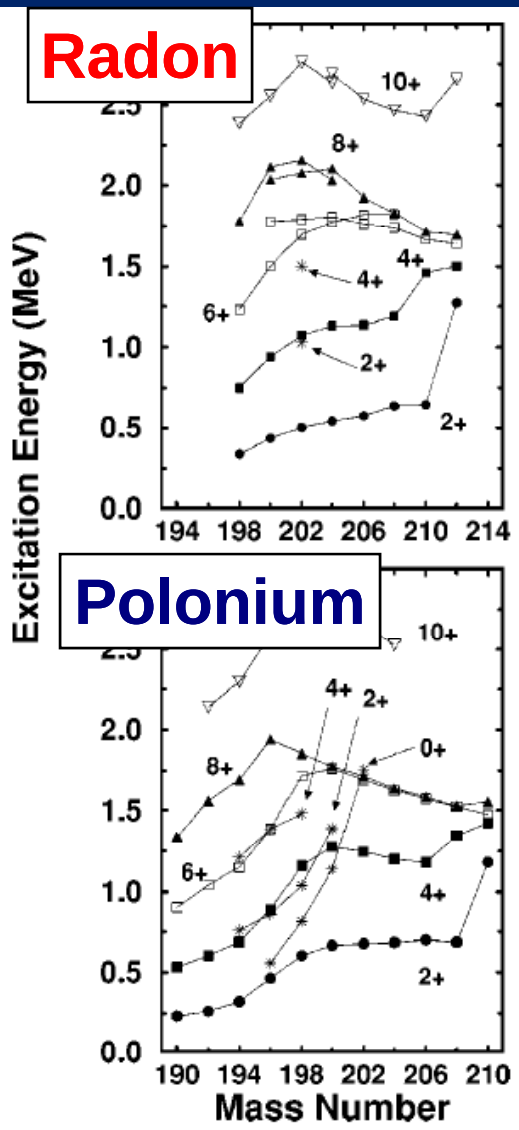
Light Polonium Isotopes





Radon Isotopes



Macroscopic-microscopic models predict that **deformed ground states** exist beyond ^{202}Rn.

$E(4^+)/E(2^+)$ ratio for **^{198,200,202}Rn** typical of an **anharmonic vibrational** system.

*S.J. Freeman et al., PRC **50** R1754 (1994)*

*R.B.E. Taylor et al., PRC **54**, 2926 (1996); PRC **59**, 673 (1999)*

Evidence found for deformed intruder states in **^{202,204}Rn** which coexist with spherical ground state.

*D.J. Dobson et al., PRC **66** 064321 (2002)*

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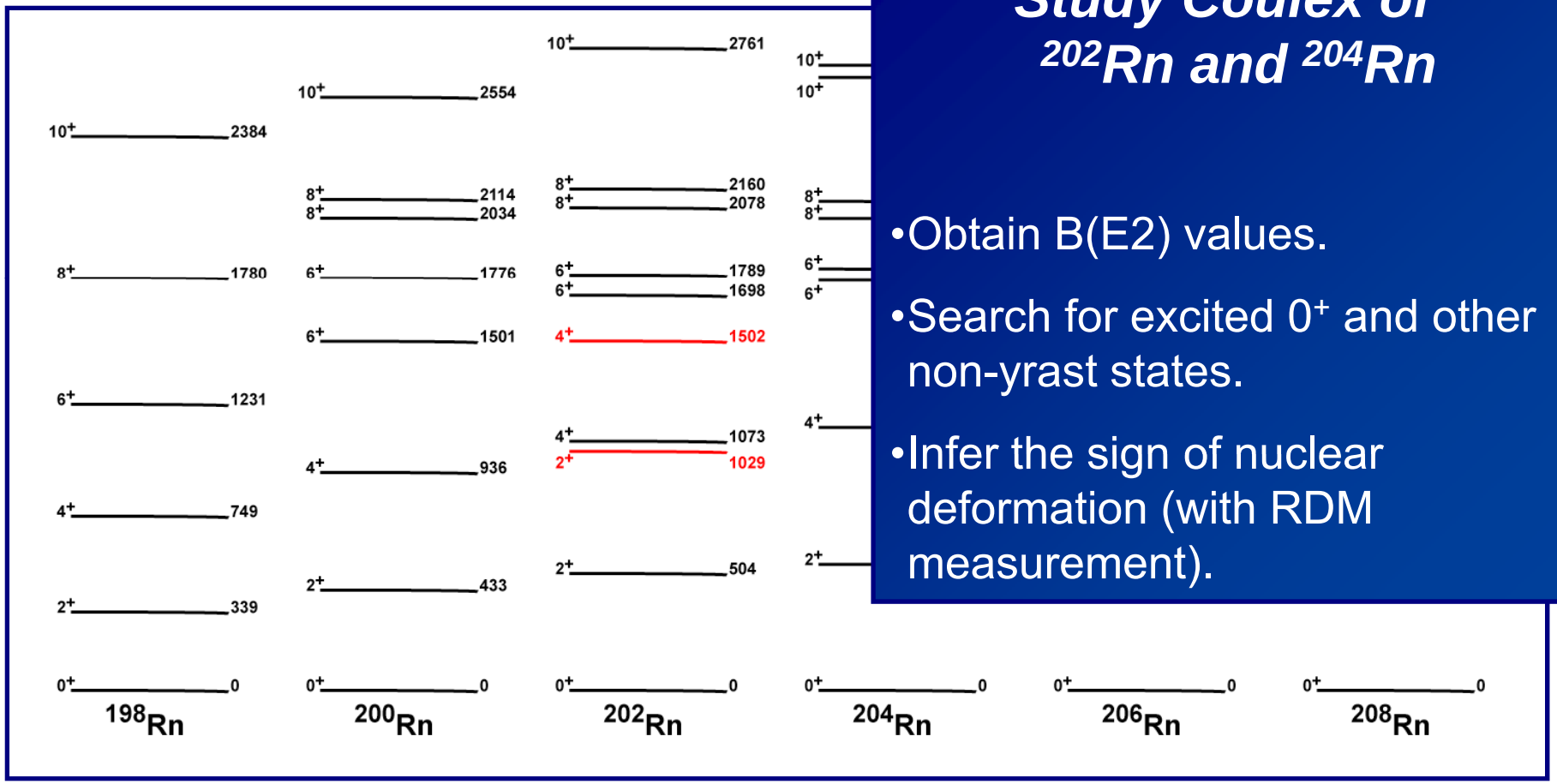
Low Lying Levels in Rn Isotopes



Study Coulex of ^{202}Rn and ^{204}Rn

- Obtain B(E2) values.
- Search for excited 0^+ and other non-yrast states.
- Infer the sign of nuclear deformation (with RDM measurement).

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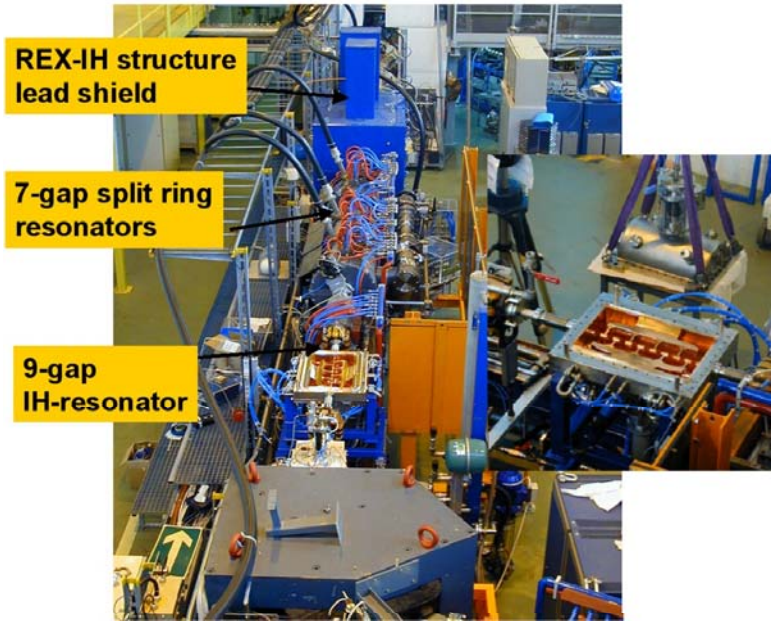
Experimental Technique

Light Radon isotopes accelerated from **REX-ISOLDE**.

^{202,204}Rn produced with good yields from **Th** primary targets.

PS Booster and ThC target:
^{202}Rn - 9 x 10^5 ions/μC
^{204}Rn - 2 x 10^7 ions/μC

Plasma cooled transfer line provides **Isobarically pure beam**.



^{208}Pb has recently been accelerated as a preparatory step for light Hg nuclei at REX-ISOLDE.

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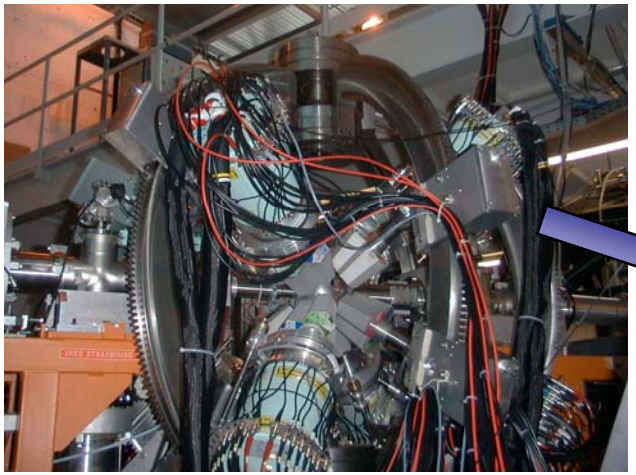
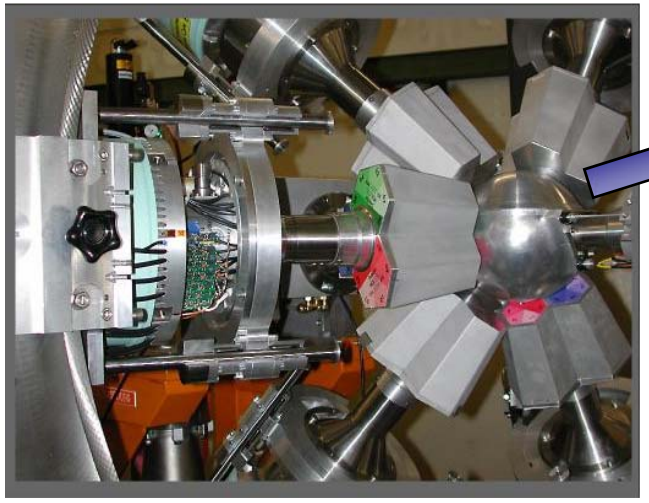
Experimental Technique



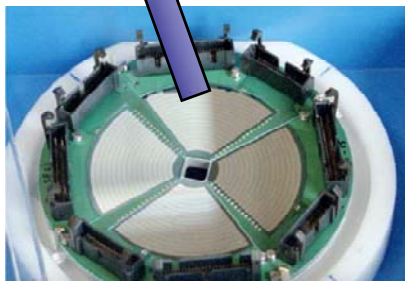


x8 Miniball clusters

CD detector
(16º-53º)

^{202,204}Rn from
REX-ISOLDE

^{120}Sn
2 mgcm^{-2}

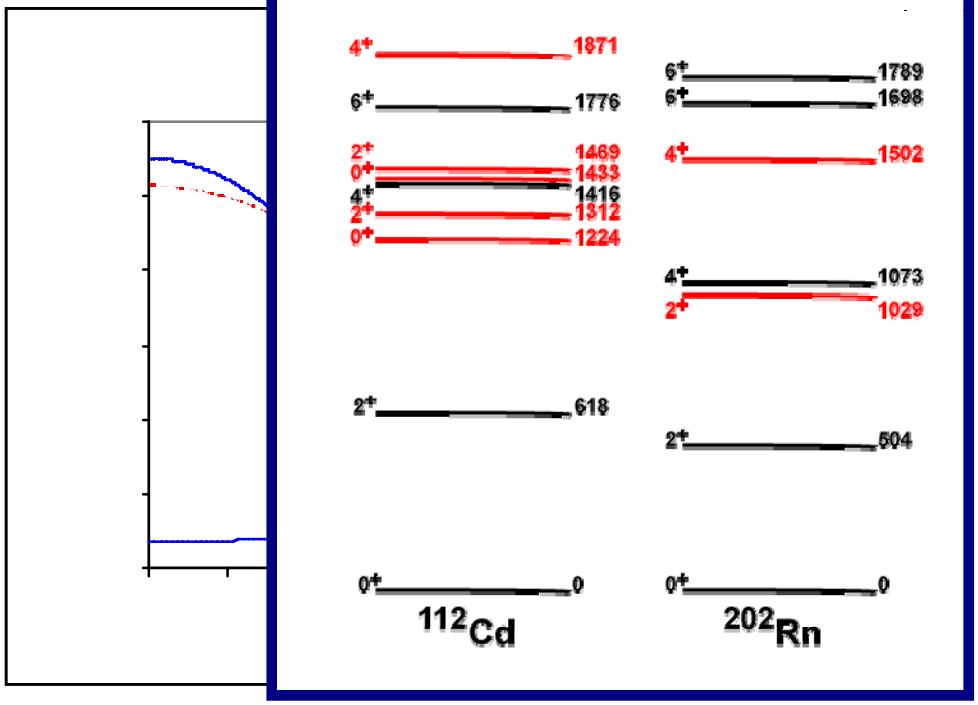


Yields

3 MeV/u ^{202}Rn beam on **^{120}Sn** Target (550 MeV centre of target)

2% transmission efficiency

Beam Curr



State	σ (mb)	γ-ray yields
2_1^+	2.55	32000
4_1^+	0.1	1200
2_3^+	0.009	100
0_2^+	0.22	2700
2_2^+	0.019	2500
4_2^+	0.00068	<10

Estimate using CLX code assuming standard Miniball setup (8 triple cluster Ge detectors and CD detector)

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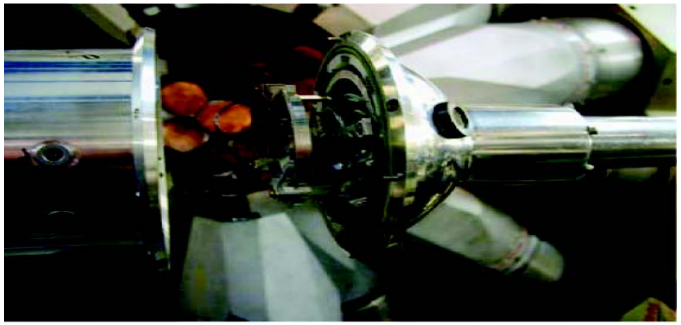
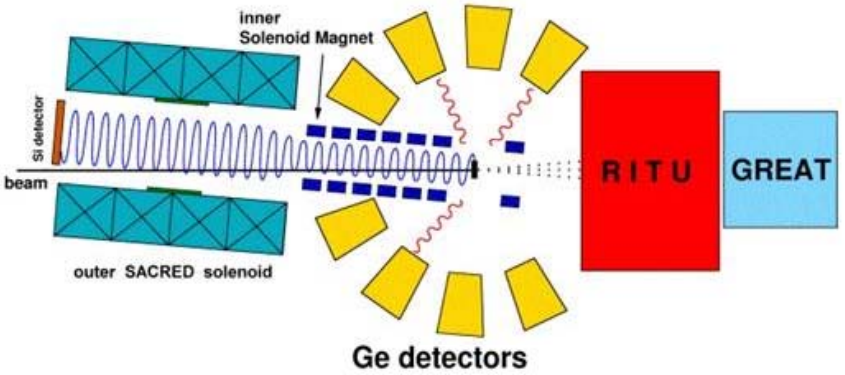
Programmatic Aspects

First of a proposed programme of **complementary measurements** using the **unique facilities** at **ISOLDE** and at the **University of Jyväskylä**.



Recoil Distance Method (RDM) measurements with plunger to obtain **independent lifetimes**. Allow full extraction of the **diagonal matrix elements**, allowing the **sign of the deformation** to be extracted

Conversion electron studies at **ISOLDE** or **SAGE Spectrometer** at Jyväskylä. Help to determine properties of **excited 0^+** states and **E0** content of **j ➔ j** transitions, related to **rms charge radius.**



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Summary

Coulomb Excitation of ^{202,204}**Rn** using **REX-ISOLDE** and **Miniball + CD**.

- Obtain **B(E2)** values.
- Search for **excited 0^+** and other **non-yrast** states.
- Infer the sign of nuclear deformation (with RDM measurement).

Beam	Min. Intensity	Target	Ion Source	Shifts
^{202}Rn	9 x 10^5 / μc	ThC	Plasma Cooled	15
^{204}Rn	2 x 10^7 / μc	ThC	Plasma Cooled	6

Radon Isotopes

Macroscopic-microscopic models predict that **deformed ground states** exist beyond ^{202}Rn.

E(4$^+$)/E(2$^+$) ratio for **^{198,200,202}Rn** typical of an **anharmonic vibrational** system.

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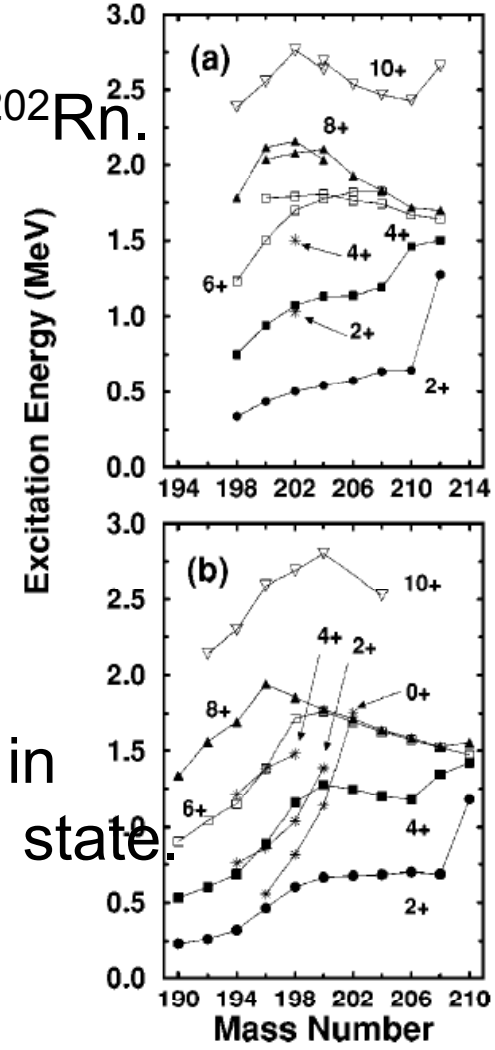
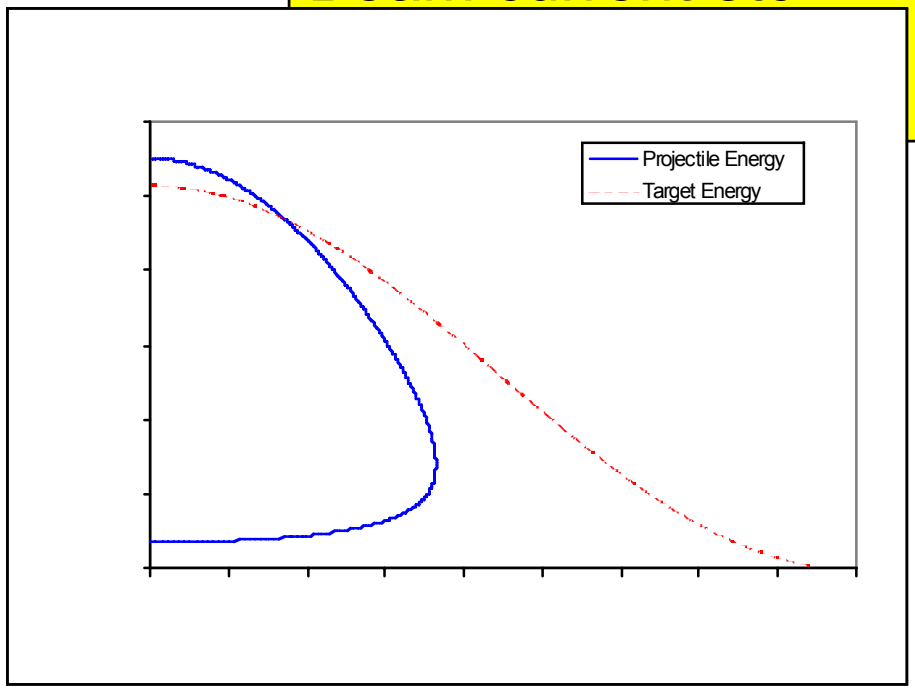
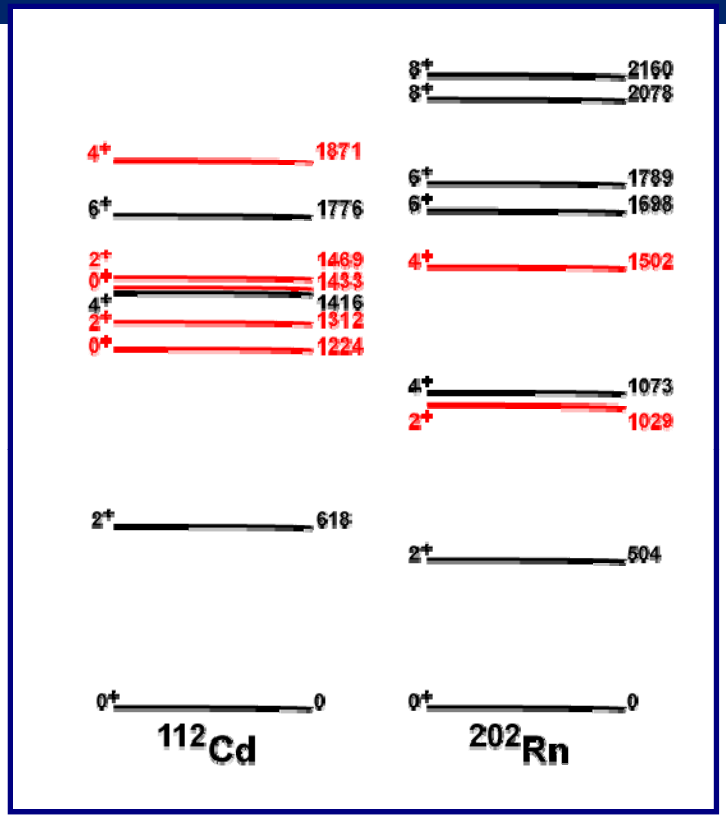


Yields

Calculations

Beam current etc





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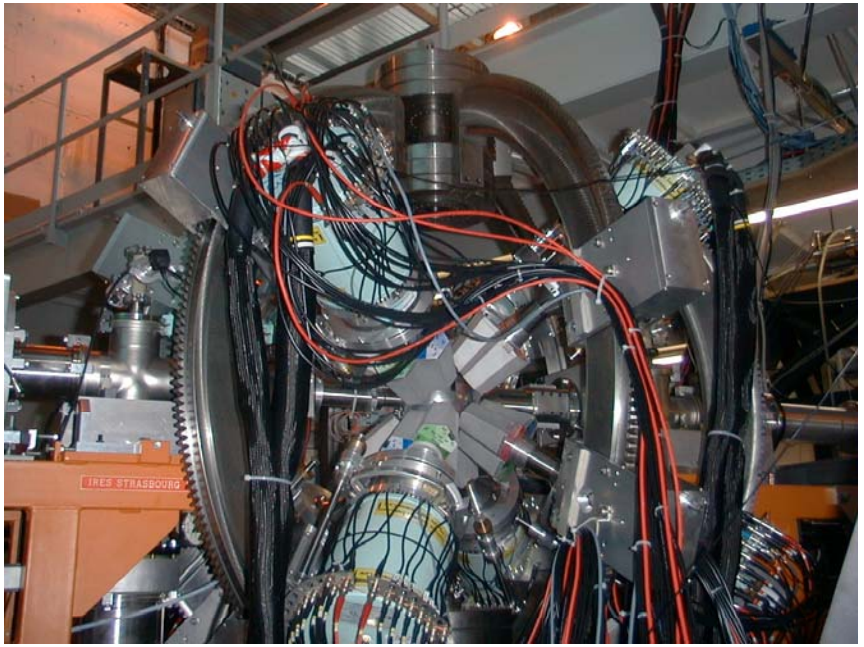
Coulomb Excitation

Why is it good ?

Details of recent successes at ISOLDE

What will it allow us to extract ?

Hg Data - similar quailty



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Programmatic Aspects

First of a proposed programme of **complementary measurements** using the **unique facilities** at **ISOLDE** and at the **University of Jyvaskyla**.

Programs etc.

SAGE this year

2+-2+ / 0+s