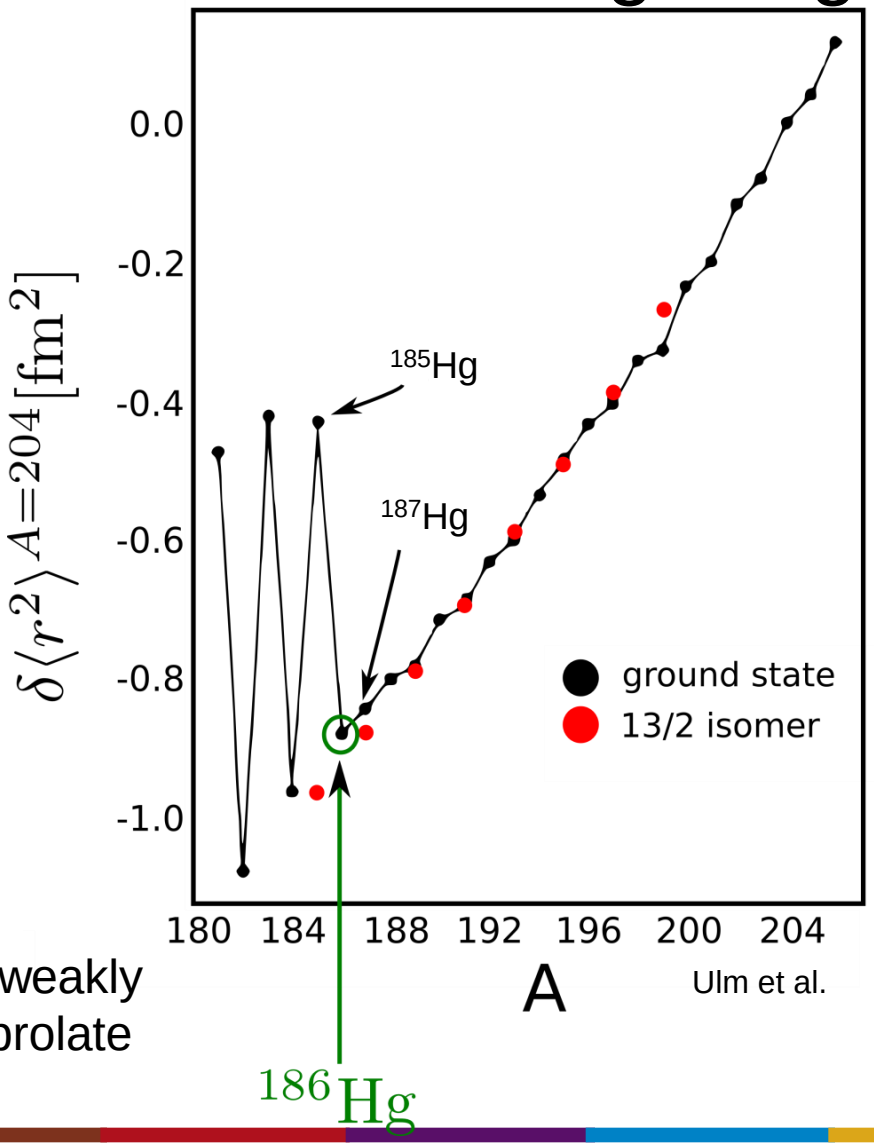
RDDS lifetime measurements of yrast states in ^{186}Hg

M.H., Christoph Fransen, Alfred Dewald, Tuomas Grahn, Marcus Scheck, Thomas Braunroth, Nick Bree, Peter Butler, Mike Carpenter, Robert Carroll, Christopher Chiara, Piet van Duppen, Fay Filmer, Liam Gaffney, Robert Janssens, Jan Jolie, Rauno Julin, Mark Huyse, Filip Kondev, Torben Lauritsen, Kim Lister, Julia Litzinger, Päivi Nieminen, Janne Pakarinen, Thomas Pissulla, Sarah Rigby, Wolfram Rother, Karl-Oskar Zell, Heidi Watkins, Shaofei Zhu

Shape Coexistence in light Hg Isotopes



Transition from a weakly oblate to a more prolate deformation

First observation:
Bonn et al. Phys Lett. 38B (1972) 5
Frauendorf et al 1975 Phys. Lett. B 55 365

Shape Coexistence in light Hg Isotopes

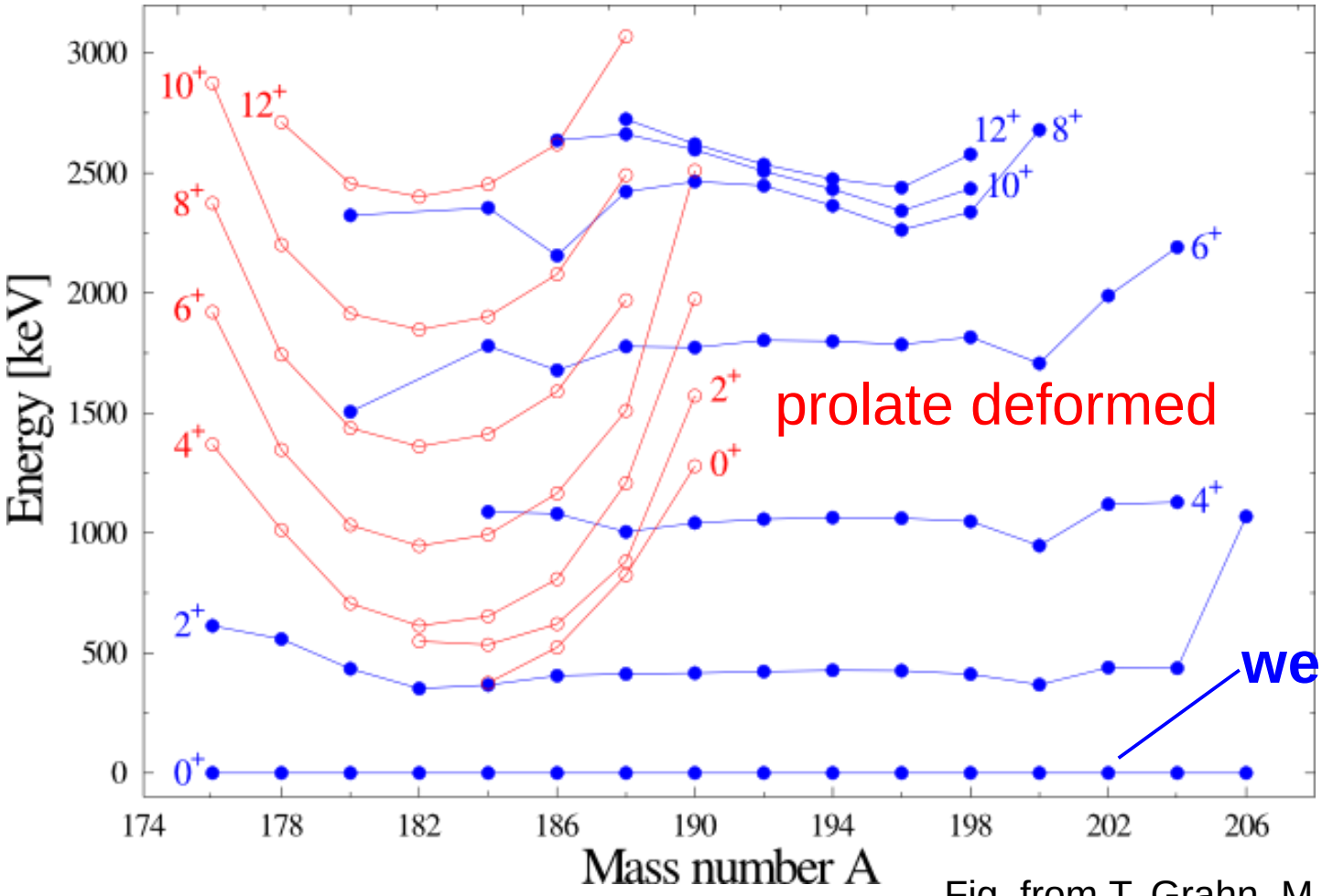
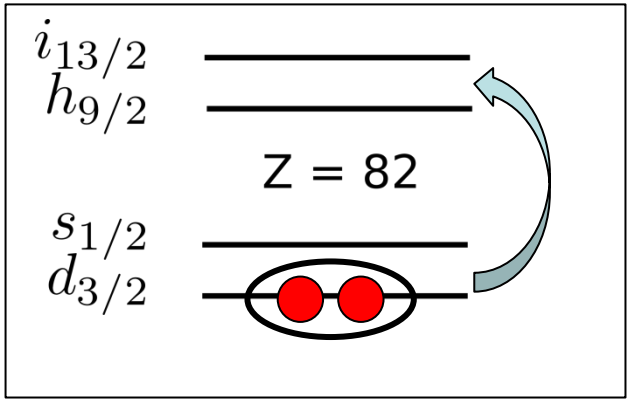


Fig. from T. Grahn, M. Scheck, R. Julin

Shape Coexistence in light Hg Isotopes

- Several theoretical approaches:
  - J.L. Wood et al Phys. Rep. 215 (1992) 101-201
  - Self-consistent **Mean Field** + particle number restauration: T. Duguet et. al.,Phys. Lett B 559 (2003) 201; M. Bender et. al., J. Phys. G: Nucl. Part. Phys. 31 (2005) S1611–S1616
  - **Rel. Mean Field + BCS**, e.g. S. Yoshida, Phys. Rev. C 55 (1997) 3
  - **IBM**, R. Fossion et. al., Phys. Rev. C 67, 024306 (2003)
  - **2p-2h excitations**, e.g., W. Nazarewicz et al Phys. Lett. B., 305 (1993) 195-201
  - Cf. also talk from D. Vretenar
- Consistently describe prolate and oblate band.



$$\hat{H} = \hat{H}_{\text{reg}} + \hat{H}_{\text{2p2h}} + \hat{H}_{\text{4p4h}} + \hat{V}_{\text{mix}}$$

$$\hat{H}_{\text{2p2h}} = \epsilon_{\text{2p2h}}\hat{n}_d + \kappa_{\text{2p2h}}\hat{Q}_{\text{2p2h}} \cdot \hat{Q}_{\text{2p2h}} + \Delta_{\text{2p2h}}$$

$$\hat{H}_{\text{4p4h}} = \epsilon_{\text{4p4h}}\hat{n}_d + \kappa_{\text{4p4h}}\hat{Q}_{\text{4p4h}} \cdot \hat{Q}_{\text{4p4h}} + \Delta_{\text{4p4h}}$$

Shape Coexistence in light Hg Isotopes

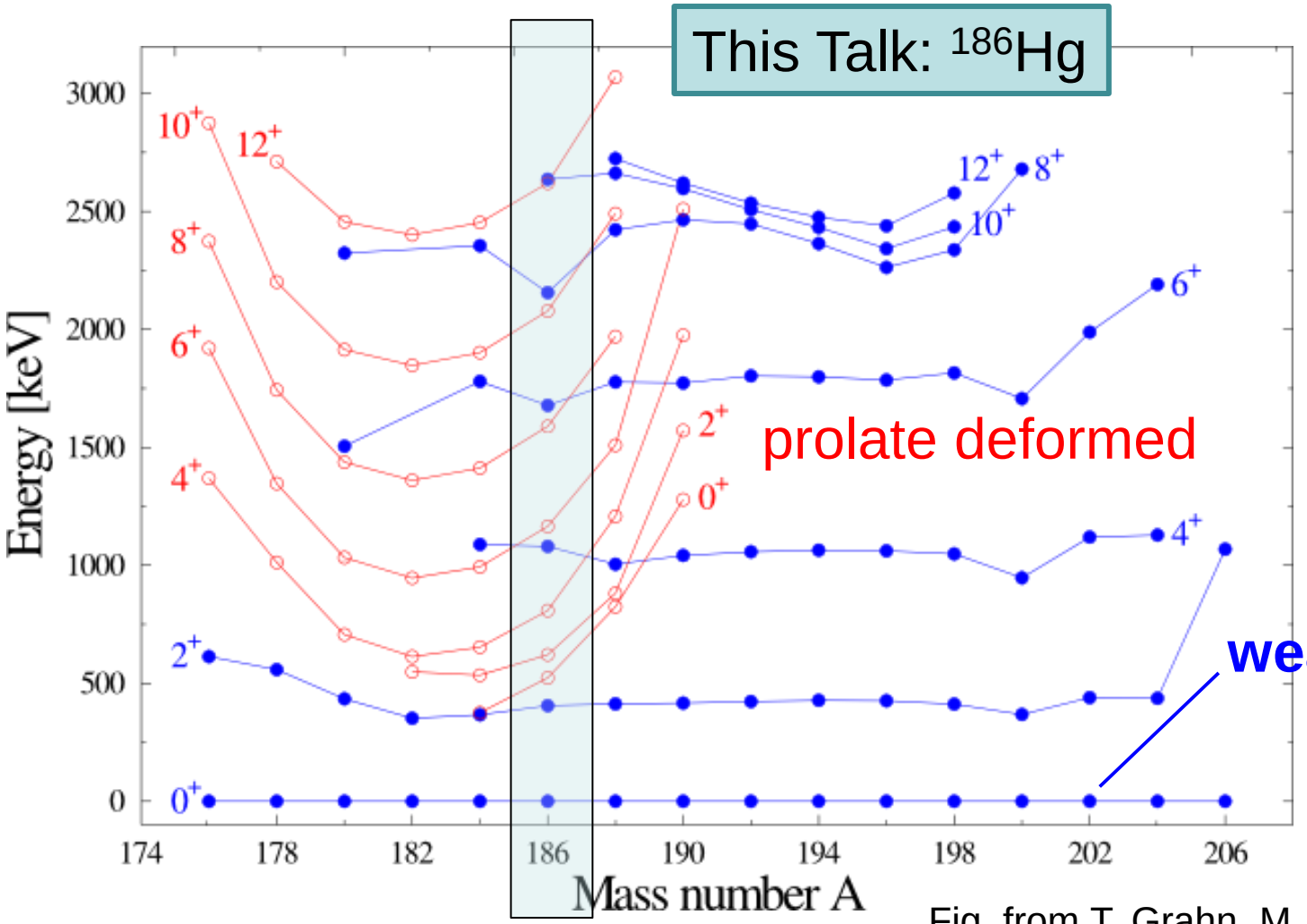
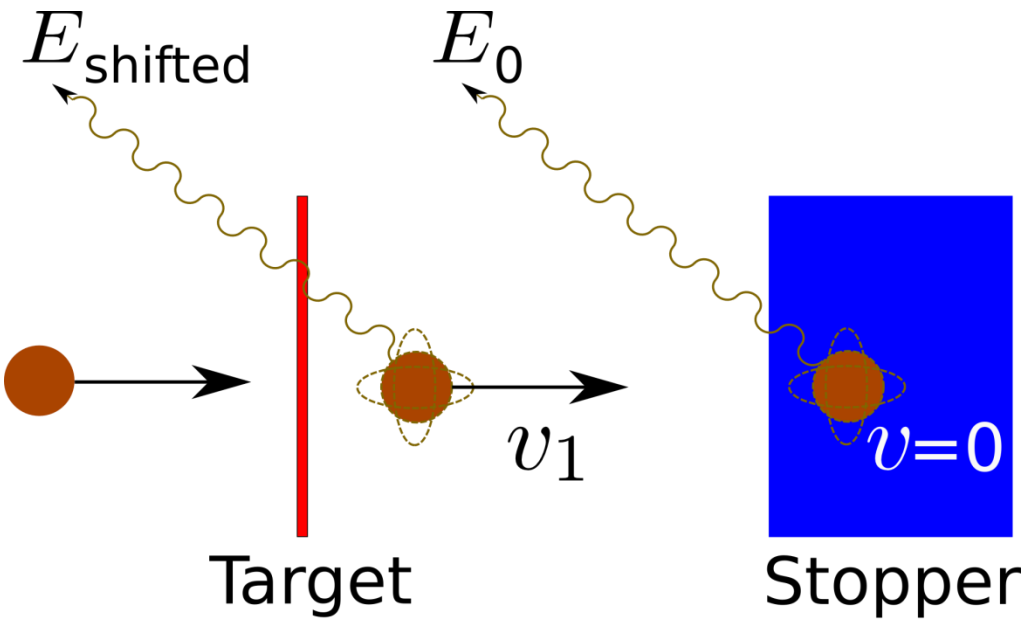


Fig. from T. Grahn, M. Scheck, R. Julin

The RDDS Method

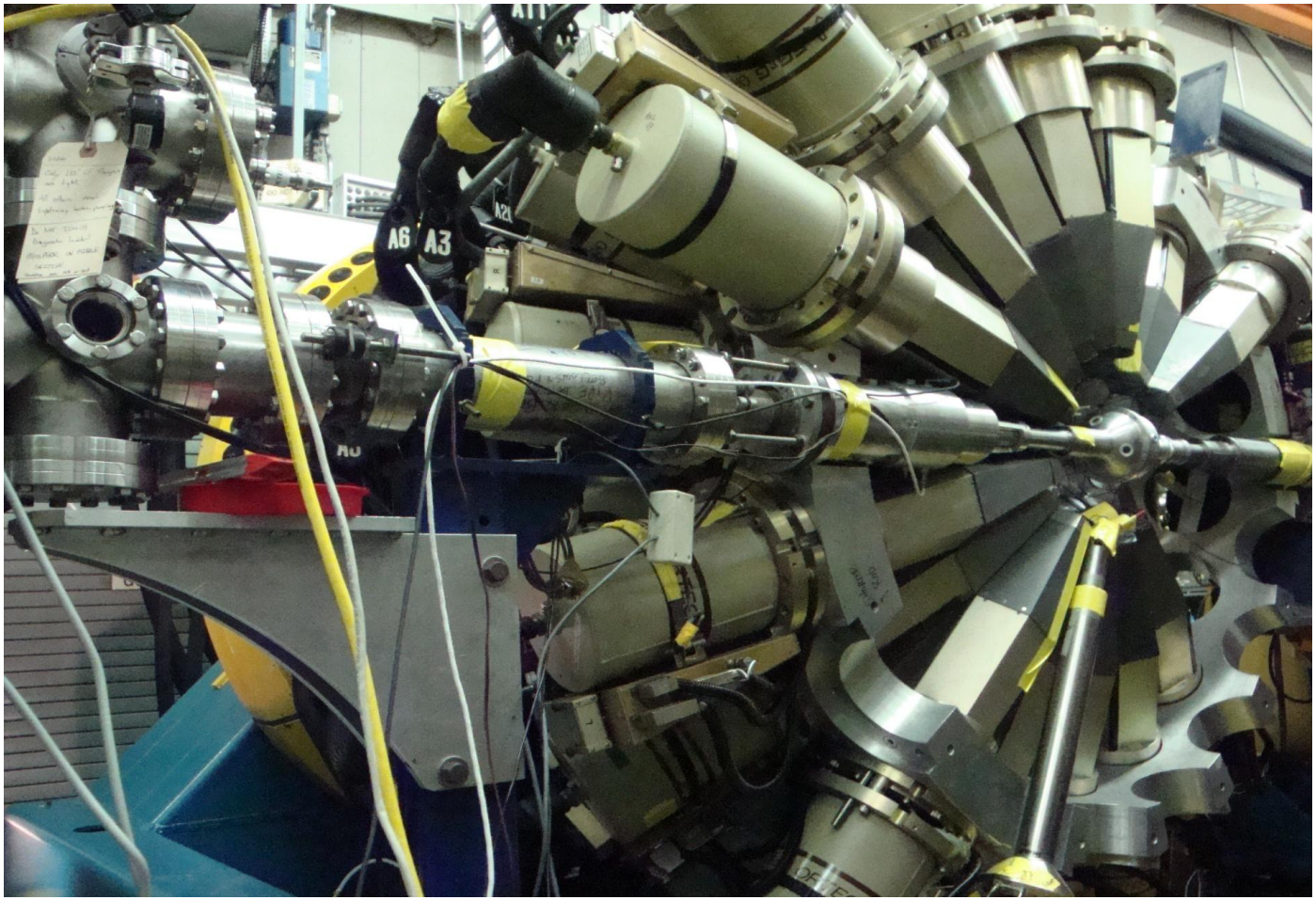
Recoil-Distance Doppler-Shift Technique



- Independent of excitation mechanism
- Different observed energies in-flight / stopped.
- Distance + Velocity + ratio flight / degraded component => Lifetime

$$E_{obs} \approx E_0 \cdot (1 + \frac{v}{c} \cos\theta)$$

Experimental Setup $^{184\text{-}188}$Hg



Plunger and Gammasphere @ Argonne National Laboratory

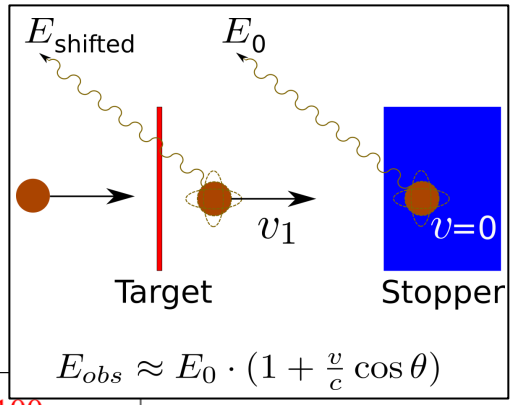
Experimental Setup $^{184\text{-}188}$Hg

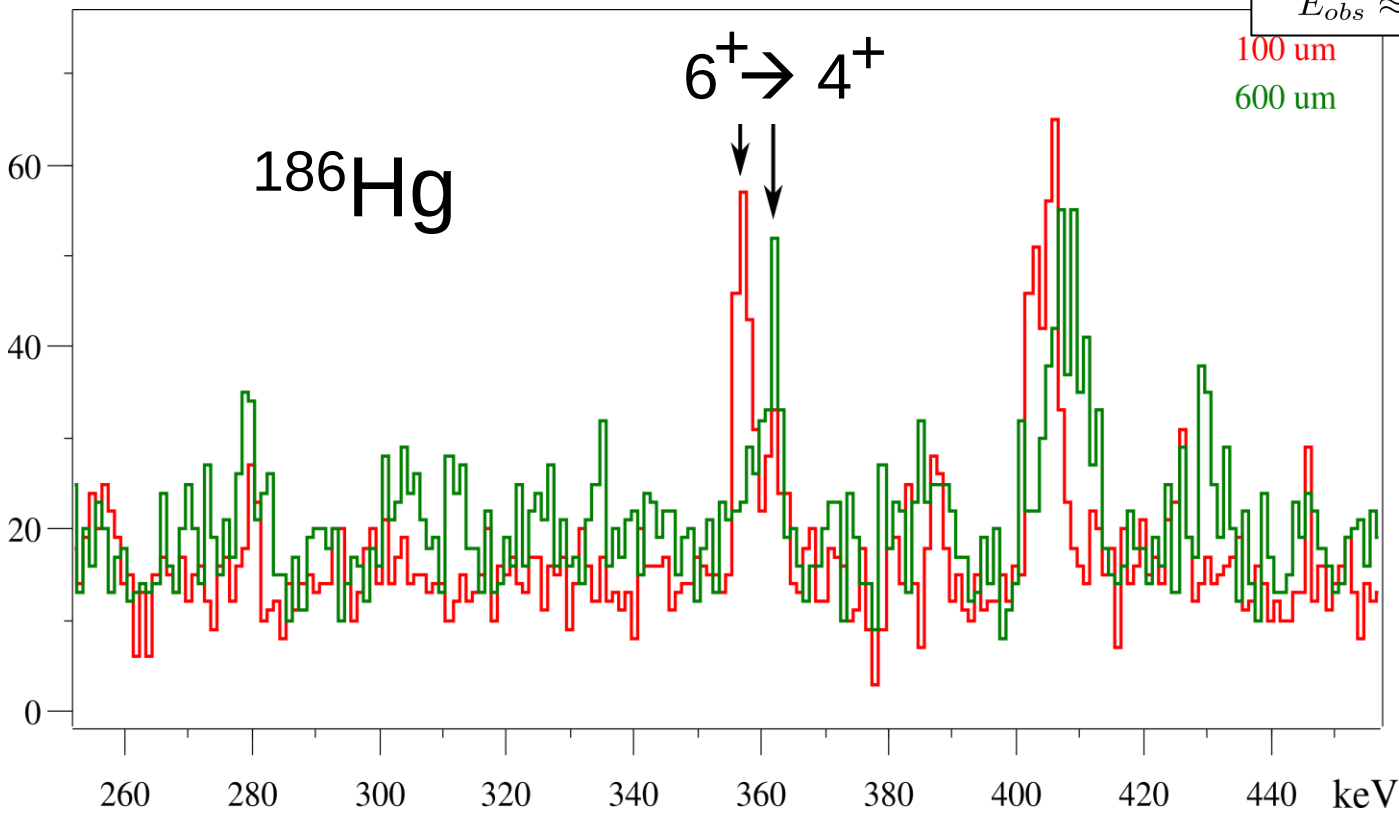
Beam: ^{40}Ar
195 MeV, 2pnA
Target:
600µg/cm^2 ^{150}Sm
On 2 mg/cm^2 Ta

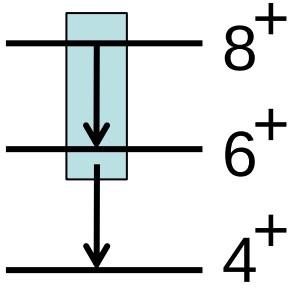
Target and Stopper

Plunger and Gammasphere @ Argonne National Laboratory

The RDDS Method

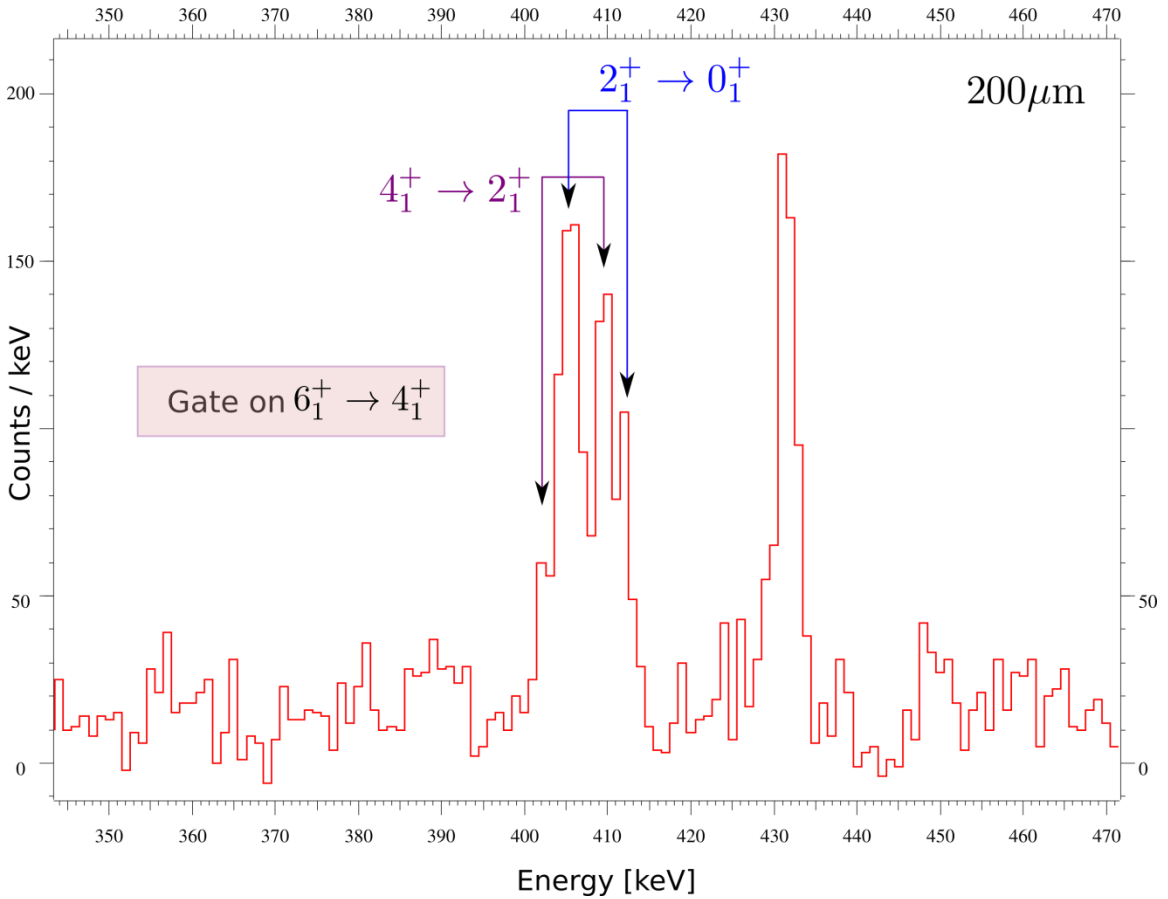


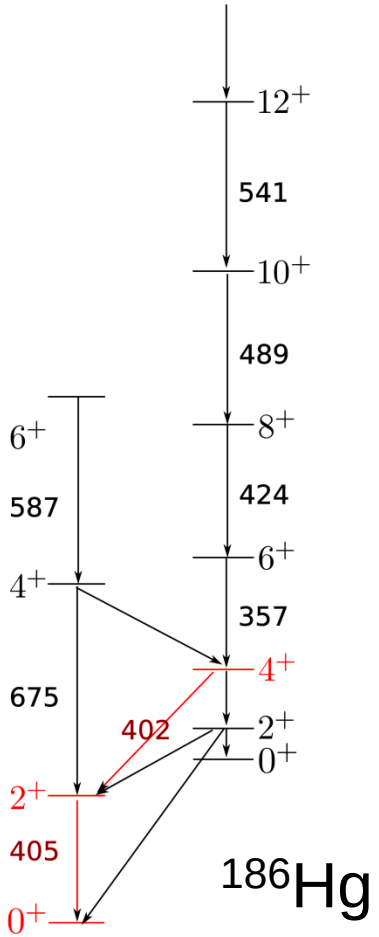




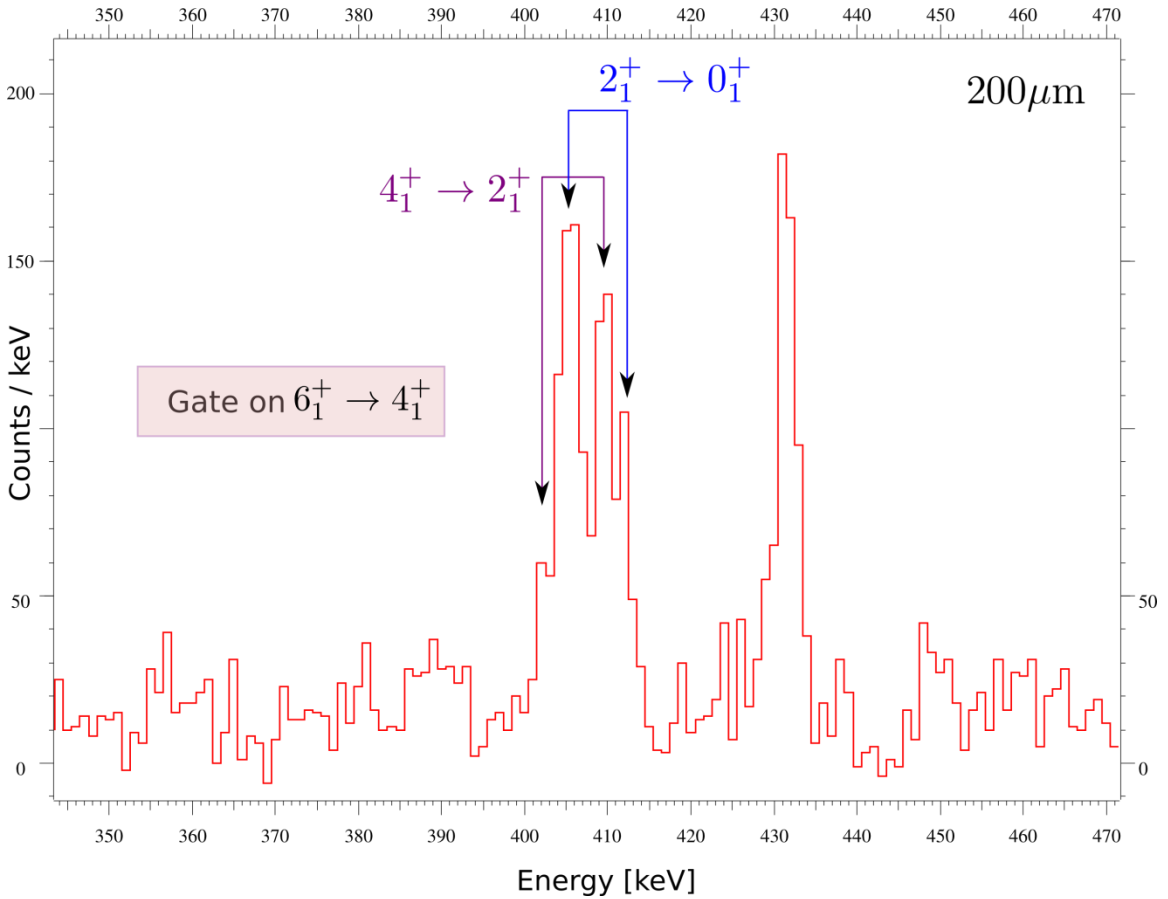
Coincidence Spectrum

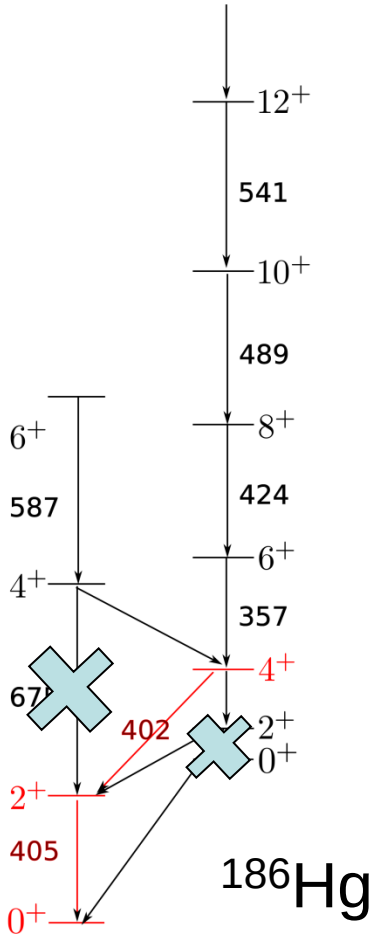
Some technical things: 4+/2+ doublet





Some technical things: 4+/2+ doublet

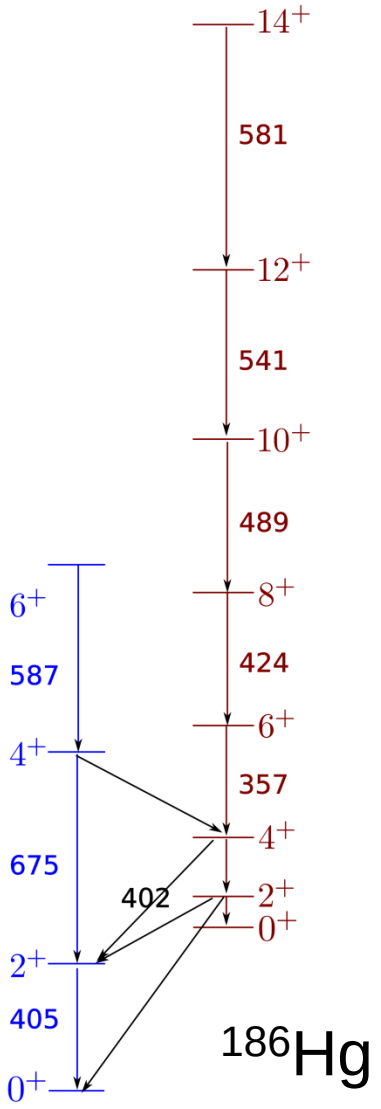




Preliminary Results

Lifetimes [ps]

State	This work	Proetel et. al.
2_1^+		26(13)
4_1^+		13(4)
6_1^+	8(1)	7(3)
8_1^+	4(1)	≈4
10_1^+	1.5(15)	--



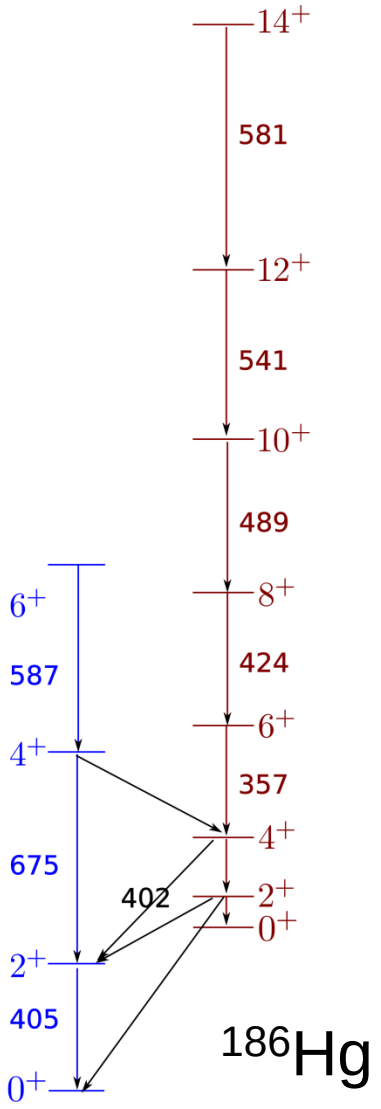
Preliminary Results

Lifetimes [ps]

State	This work	Proetel et. al.
2_1^+		16(13)
4_1^+		13(4)
6_1^+	8(1)	7(3)
8_1^+	4(1)	≈4
10_1^+	1.5(15)	--

Preliminary!

Too early for a conclusion.



Collaboration:

Institut für Kernphysik, Universität zu Köln, Cologne, Germany
C. Fransen, A. Dewald, T. Braunroth, J. Jolie, J. Litzinger, M.H., Th. Pissulla, W. Rother, K. O. Zell

INRNE, Bulgaria
P. Petkov

Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany
M. Scheck

Oliver Lodge Laboratory, University of Liverpool, UK
P. Butler, L. Gaffney, T. Grahn, M. Scheck, R. Carroll, F. Filmer, S. Rigby, H. Watkins

Jyväskylä, Finland
T. Grahn, P. Nieminen, R. Julin

Argonne National Laboratory, Argonne, IL, USA
M. Carpenter, R. Janssens, F. Kondev, T. Lauritsen, K. Lister, S. Zhu

Katholieke Universiteit Leuven, Leuven, Belgium
N. Bree, P. Van Duppen, M. Huyse

CERN, Switzerland
J. Pakarinen

Vi ringrazio per l’attenzione.

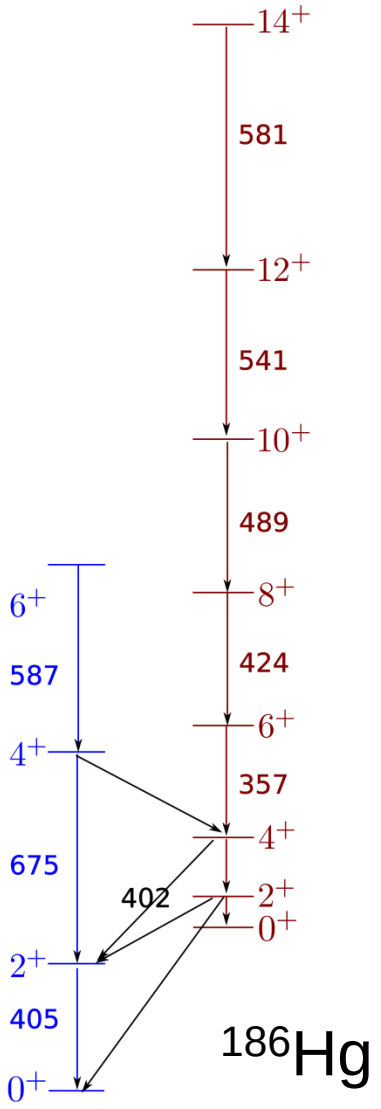
Thank you for your attention.

Je vous remercie de votre attention ! ご清聴ありがとうございました！感谢您的关注！Grazie per la vostra attenzione! Gracias por su atención! Thank you for your attention! Kiitos mielenkiinnosta! Tack för er uppmärksamhet! Спасибо за Ваше внимание! Ju faleminderit për vëmendjen tuaj! Σας ευχαριστώ για την προσοχή σας! !شكرا لاهتمامكم

Preliminary Results

Deformation parameter β

State	This work	Proetel et. al.
2_1^+		
4_1^+		
6_1^+	0.24(2)	0.27(5)
8_1^+	0.23(5)	≈0.22
10_1^+	0.25(25)	--



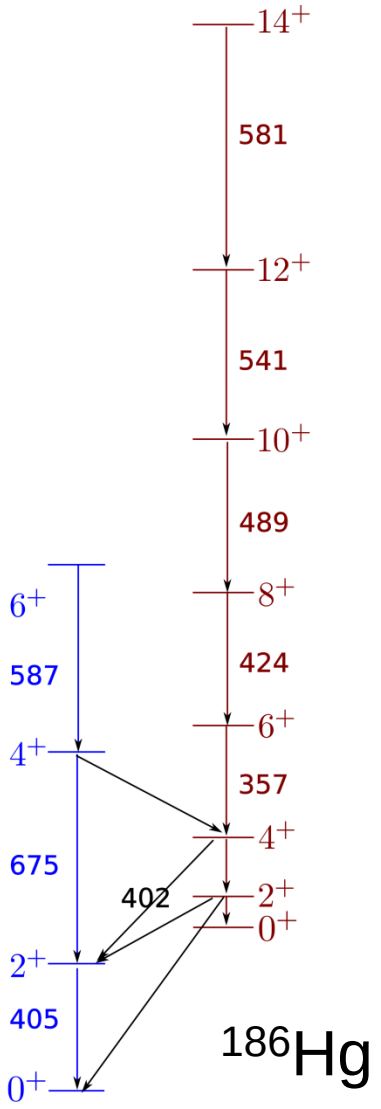
Preliminary Results

Deformation parameter β

State	This work	Proetel et. al.
2_1^+		
4_1^+		
6_1^+	0.24(2)	0.27(5)
8_1^+	0.23(5)	≈0.22
10_1^+	0.25(25)	--

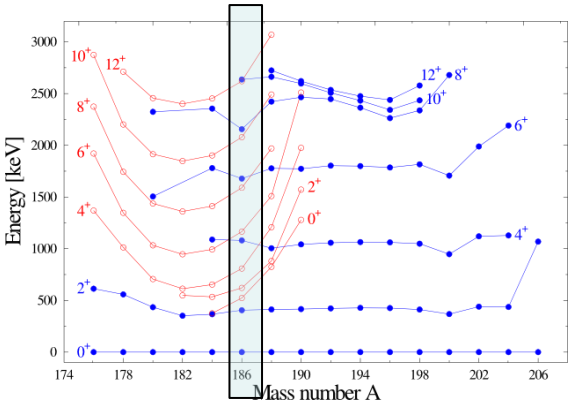
Preliminary!

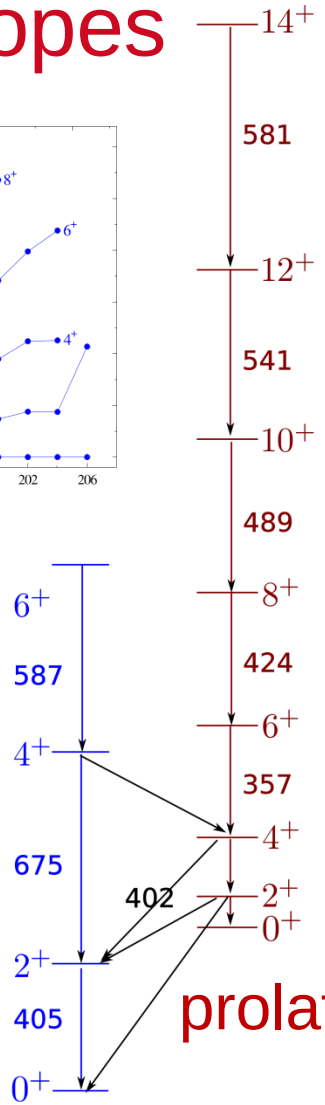
Too early for a conclusion.



Shape Coexistence in ^{186}Hg Isotopes

- This Talk:
  - ^{186}Hg: Measurement of lifetimes of excited states.
  - Motivation: Transition strengths to test the picture of shape coexistence and deformations.
- Reduce error-bars of lifetimes

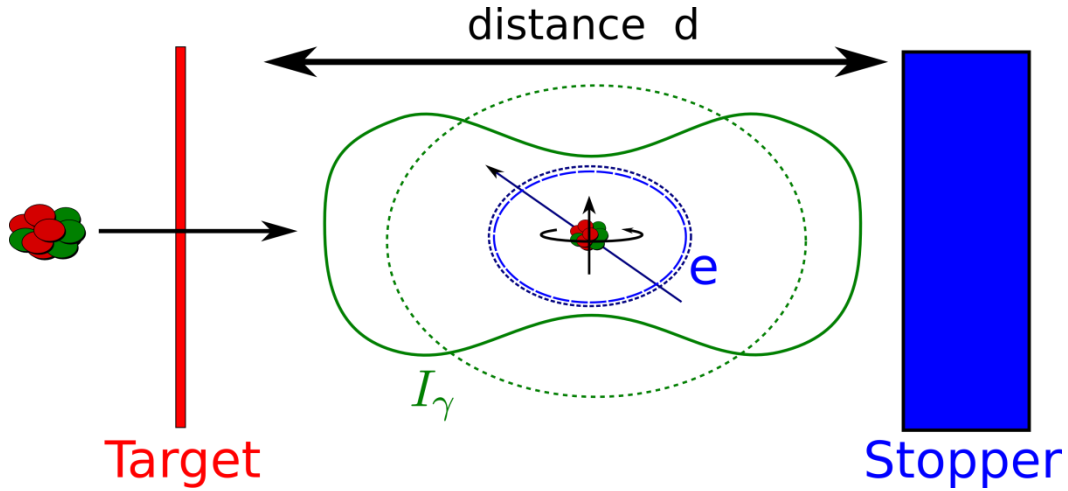




prolate, β≈0.3

oblate, β≈-0.15

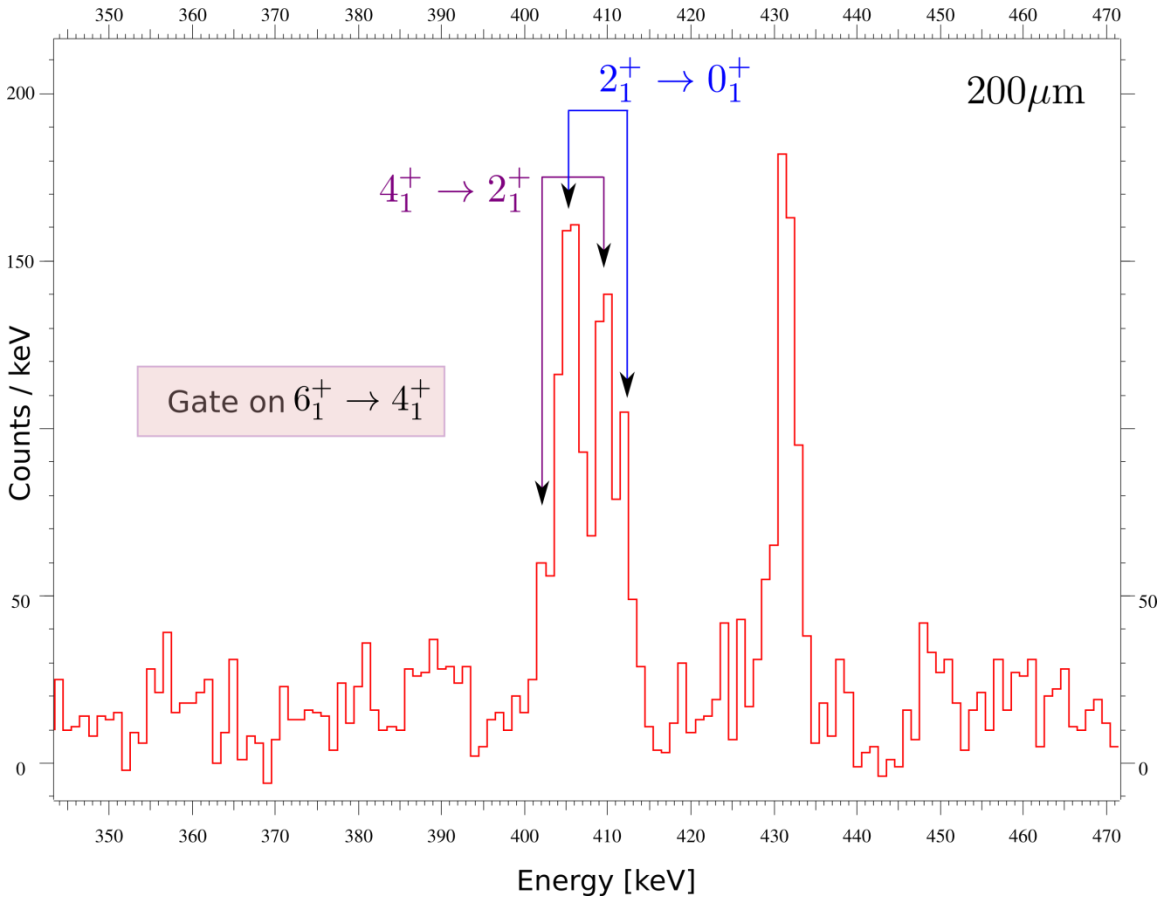
Deorientation

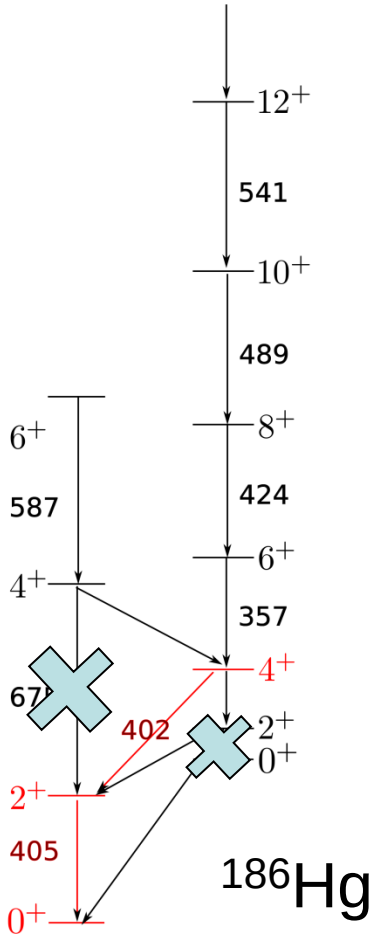


- Hyperfine interaction **I** • **J**
  - Magn. Zustand

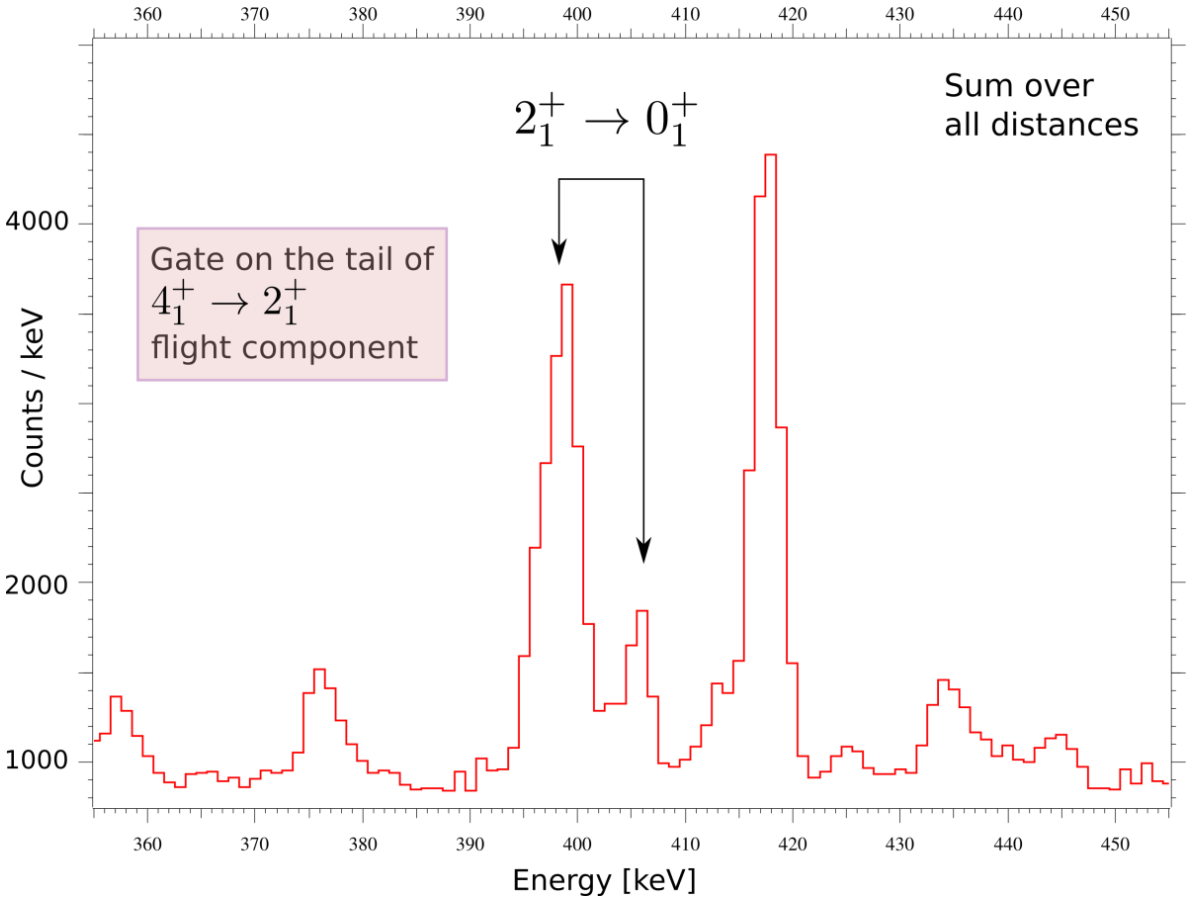
    $m = 0 \rightarrow m = -I \ldots I$
  - Angular distribution (at a specific angle) changes with distance
  - Empirical correction … *in progress*

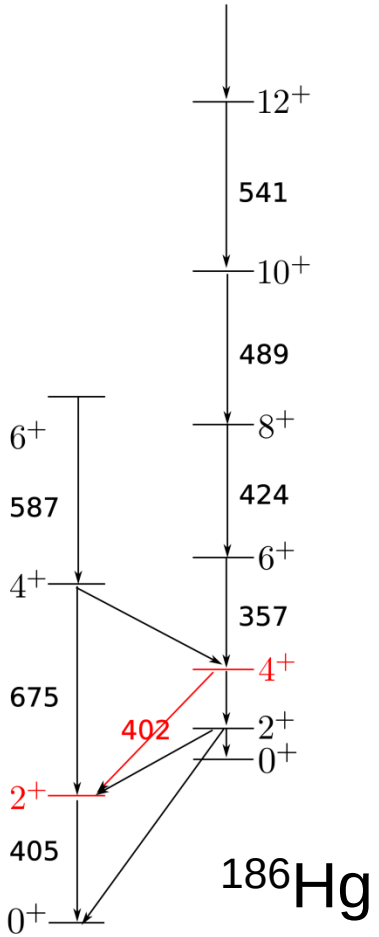
Some technical things: 4+/2+ doublet





Some technical things: 4+/2+ doublet

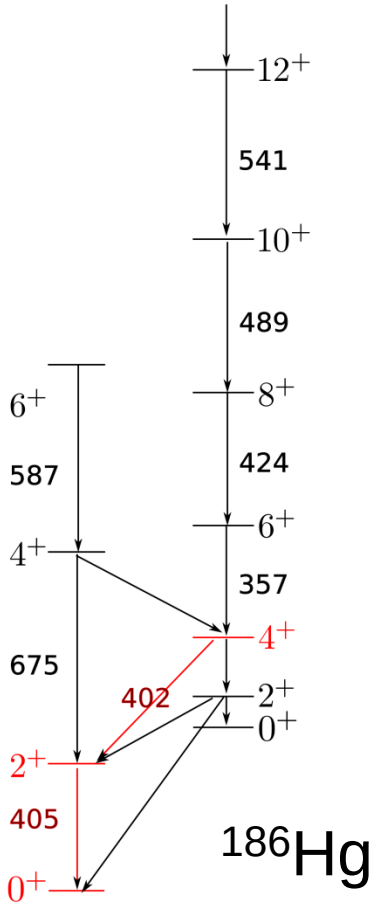




Possible, but all of the statistics needed, FW+BW rings

Some technical things: 4+/2+ doublet

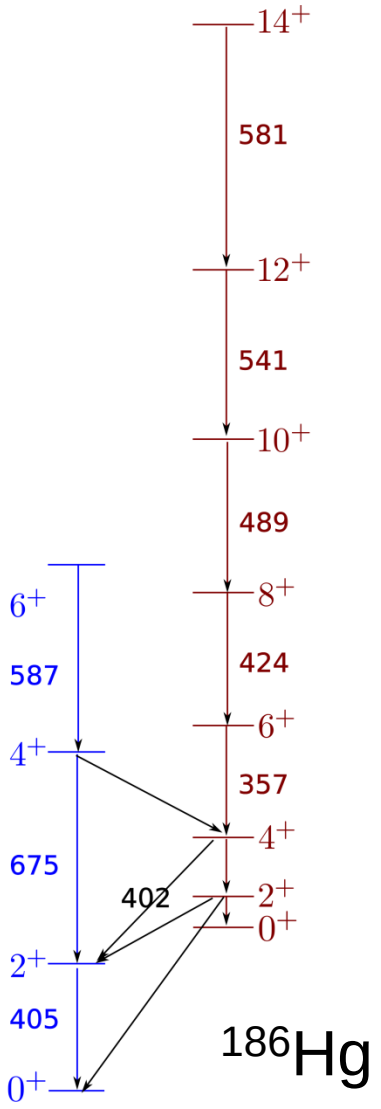
- 4_1^+: standard analysis by gating from above or below not possible here
- Possibilities:
  - Line-shape analysis
  - Ratio from 90 deg + Analysis of Sum-Peak
  - Ratio from long distances + Analysis of Sum-Peak
- 4_1^+ lifetime is possible, first (very preliminary) result: 21(5) ps.
- Problem: Deorientation



Preliminary Results

Lifetimes in ps

State	This work	Proetel et. al.
2_1^+	14(2)	26(4)
4_1^+	21(3)	13(4)
6_1^+	8(1)	7(3)
8_1^+	4(1)	≈ 4
10_1^+	1.5(15)	--

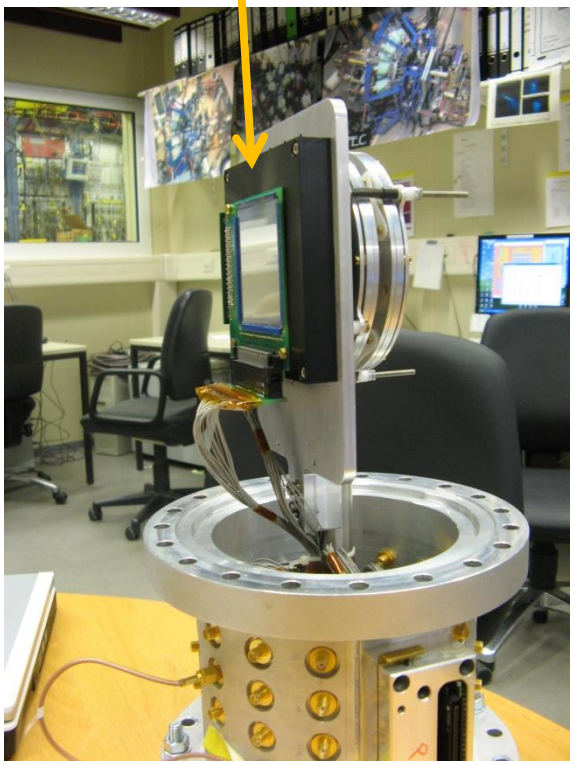


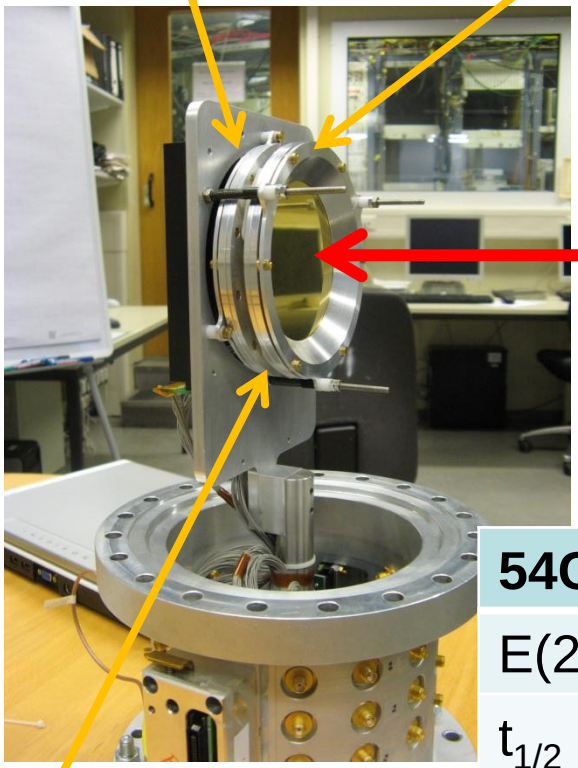
Plunger @ GSI

Target - DSSD

Ir Degrader (0,5 mm)

Au Target (1 mm)





Beam

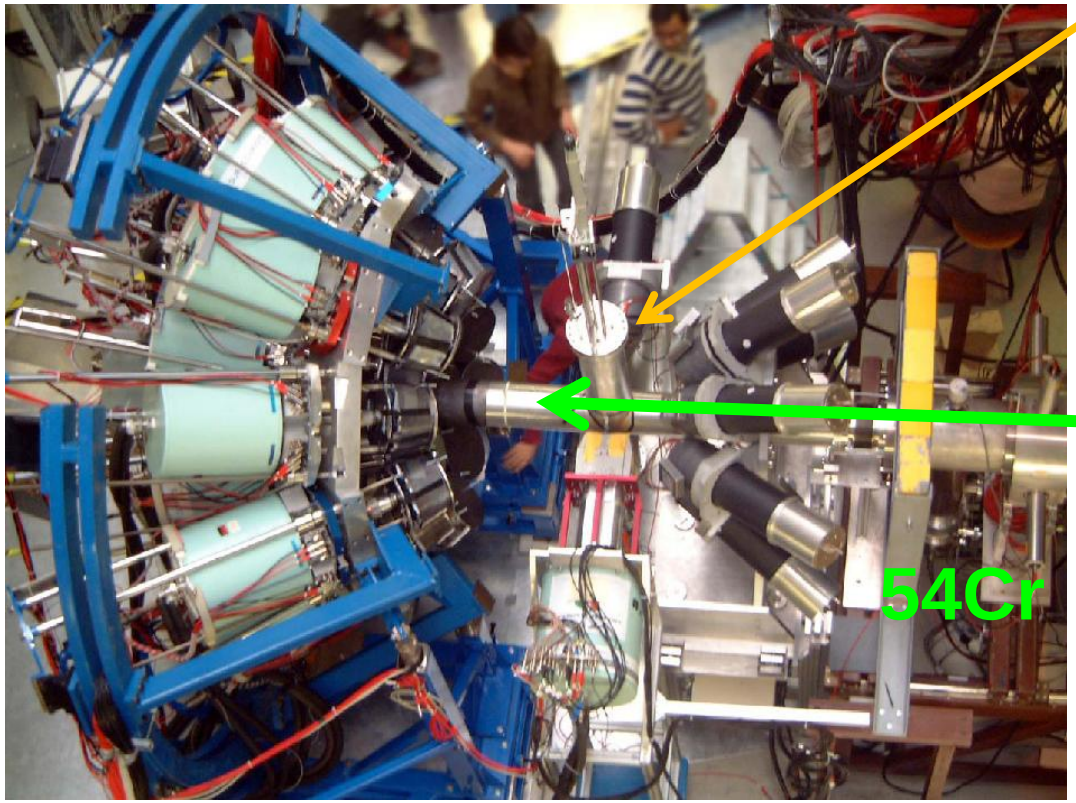
^{54}Cr

(not actually in this room)

54Cr	
E(2+)	835 keV
$t_{1/2}$	7.9 ps
β	0.55

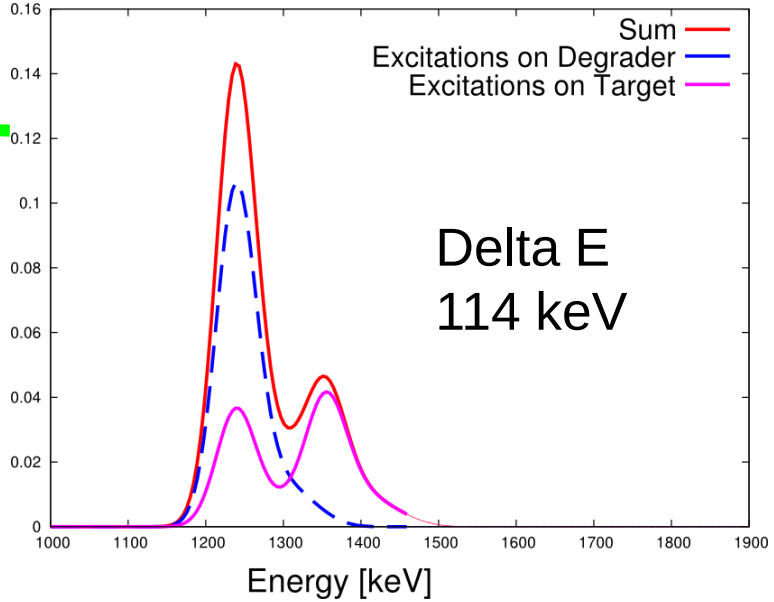
Separation 700 um

Plunger @ GSI



Target Position
(different Target chamber)

Expected Lineshape

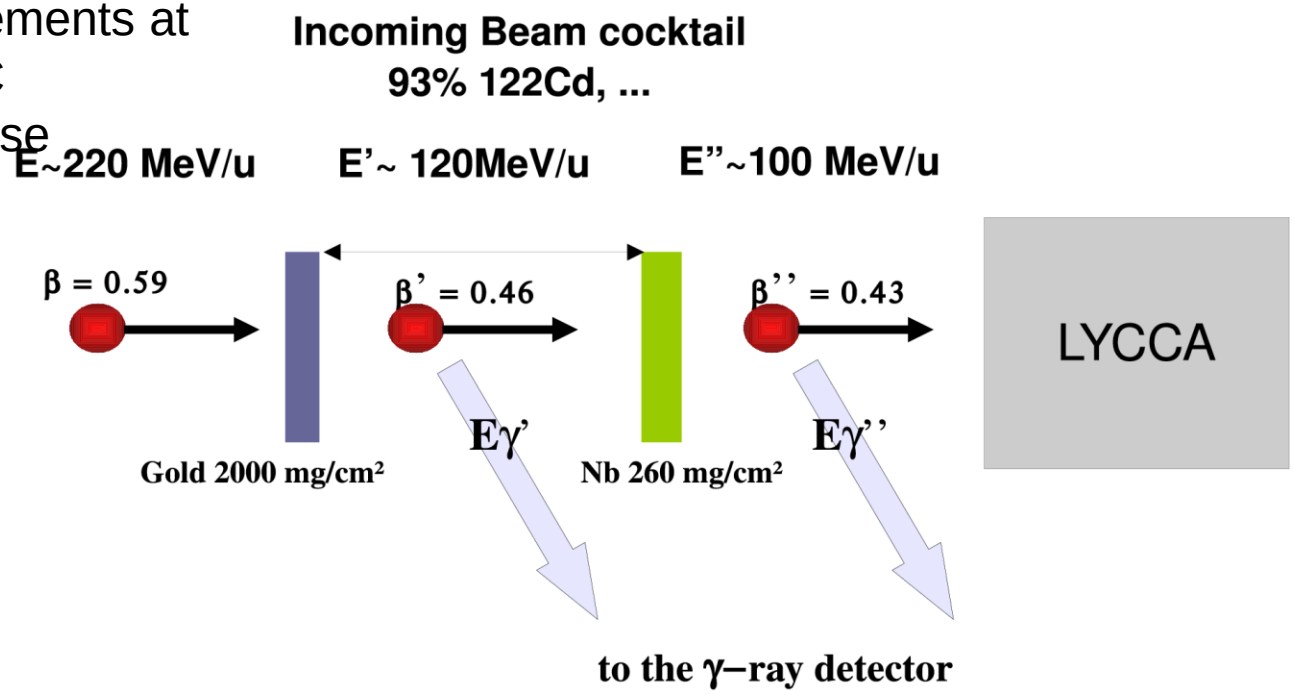


About 10 h Beamtime
We expect 700 good counts / peak
(inner Ring)

Analysis in progress…

$^{122\text{-}126}$Cd with Plunger and PRESPEC

Aim: application of Cologne differential plunger
for lifetime measurements at HISPEC/PRESPEC
with Coulex in inverse kinematics



Measure B(E2,0_1^+ -> 2_1^+) in ^{122}Cd:

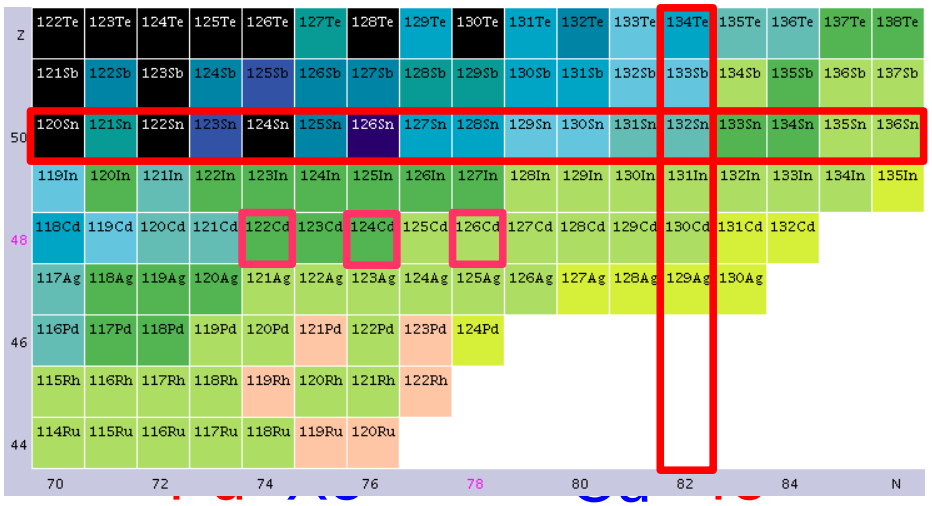
Determine from lifetimes measured with plunger

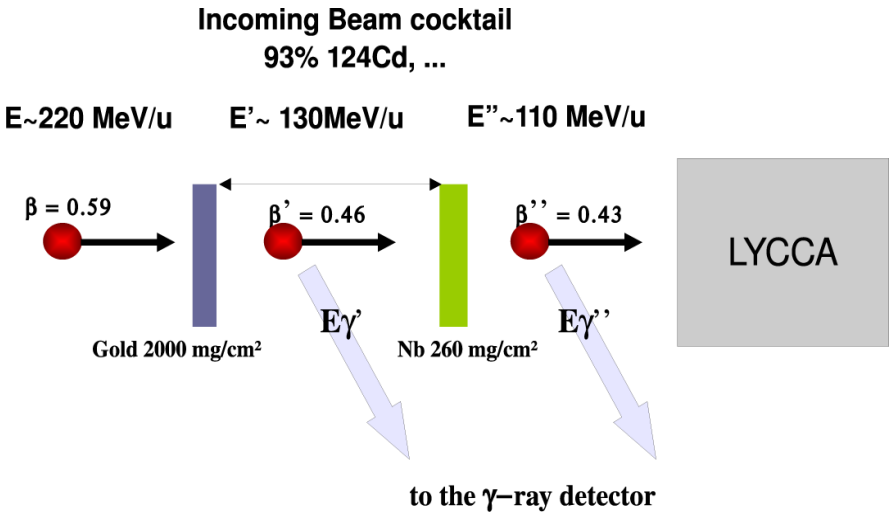
Compare to B(E2,2_1^+ -> 0_1^+) from Coulex

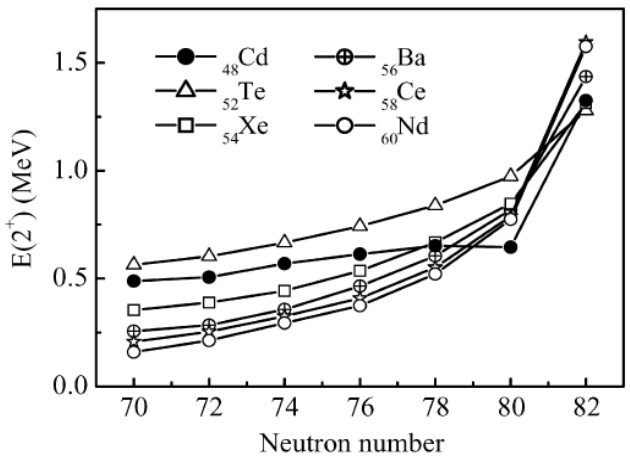
Approved parasitic experiment
21 parasitic shifts (Spring 2011)

Outlook: Investigation of neutron rich Cd isotopes at GSI with RDDS and the new AGATA array at PRESPEC

2. Letter of Intent:
measurement of B(E2) in ^{124,126}Cd in inverse kinematics Coulex with differential plunger



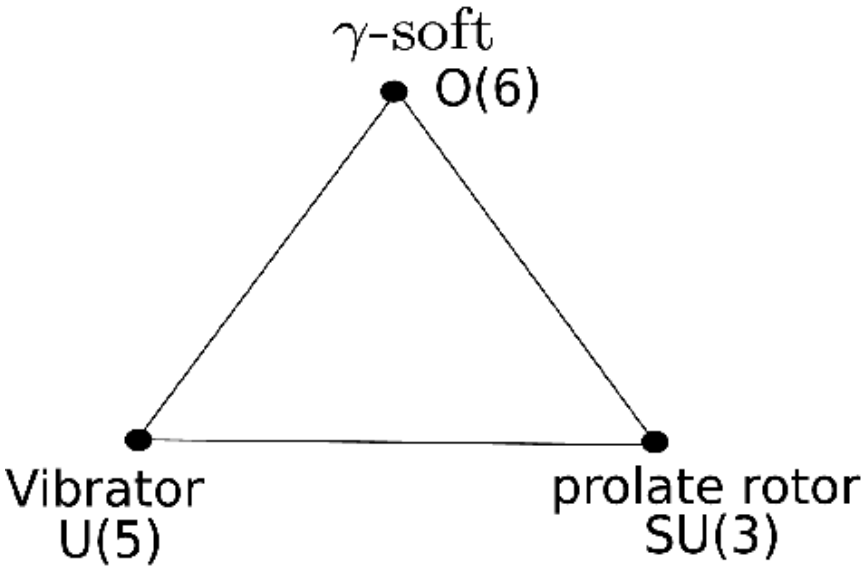




- Investigate collectivity when approaching N=82
- B(E2,2_1^+ -> 0_1^+) related to nuclear quadrupole deformation
- Milestone in understanding properties of these nuclei
- Anomalous behavior of 2_1^+ in n-rich Cd

Need f[illegible]a on B(E2,2_1^+

Testing the E(5) symmetry in ^{128}Xe



Bohr-Hamilton:

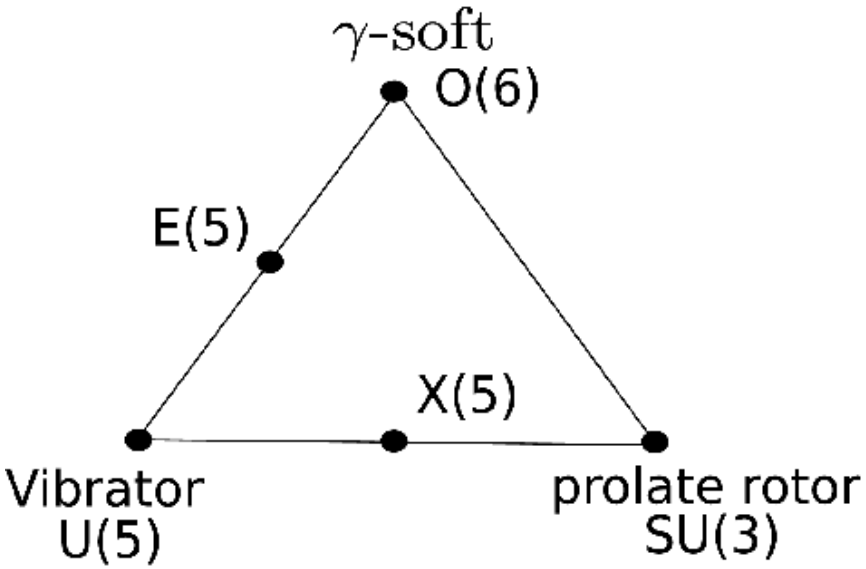
H = T + V_PO + V_NA + V_S

Limits of the Bohr-Hamiltonian

E(5),X(5): Special Potential: Analytic solution

Critical points: E(5),X(5) [1] and O(6) [2]

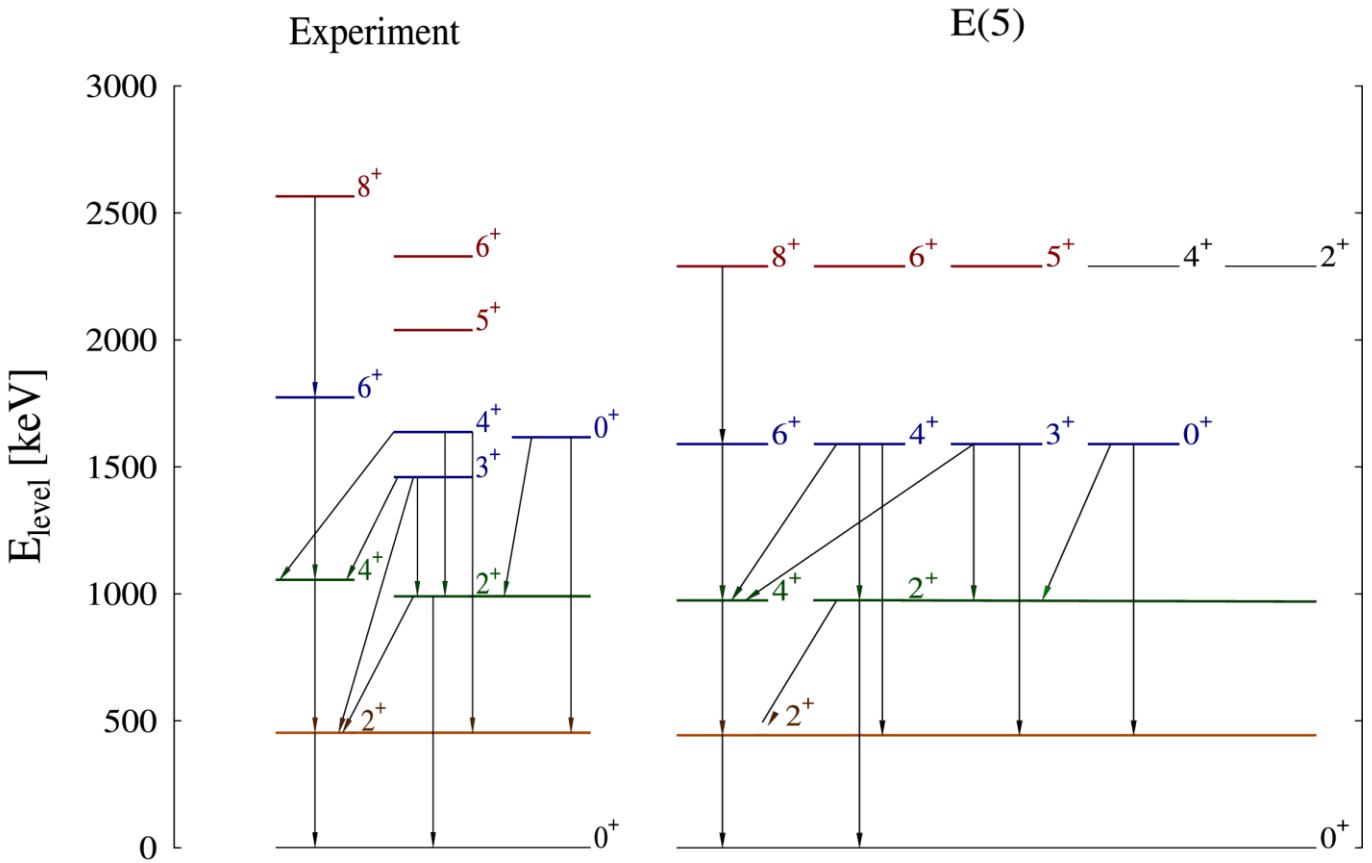
Testing the E(5) symmetry in ^{128}Xe



Symmetry Triangle

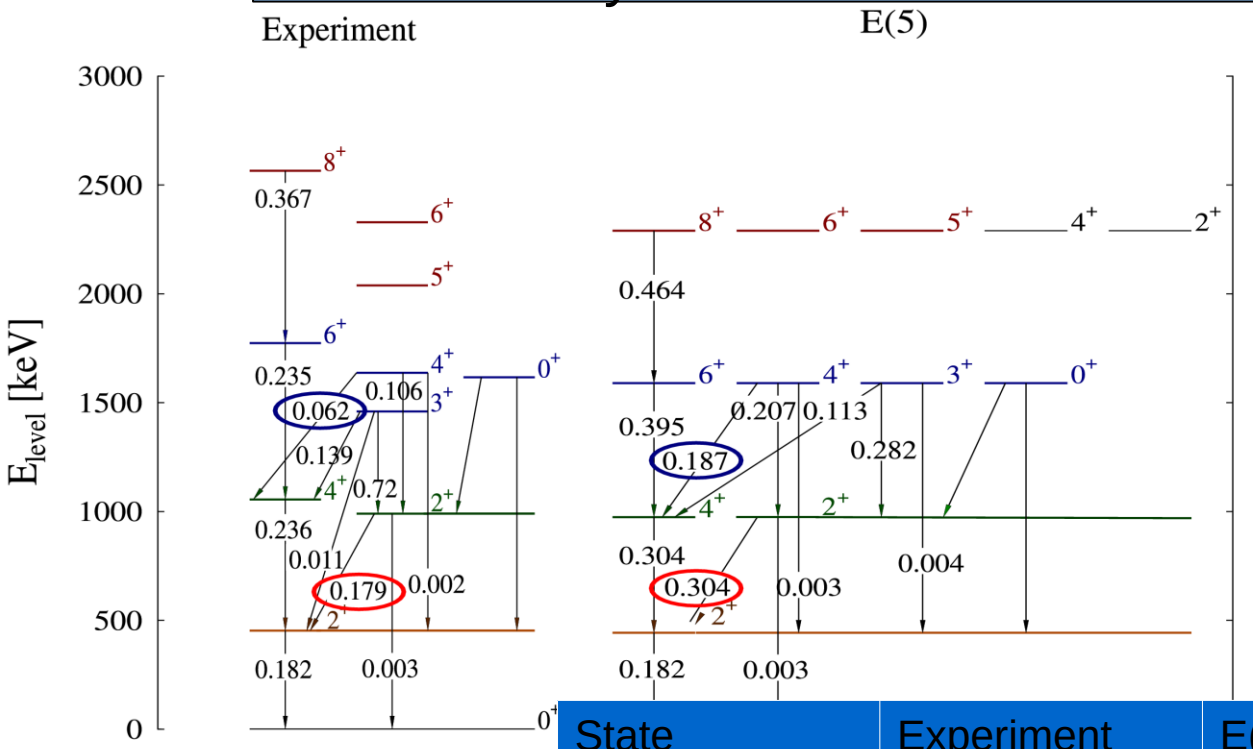
[1]: lac00

The E(5) Symmetry



Experimental Results

Lifetimes and Quadrupole Moments using RDDS – Analysis + Coulex cross sections (GOSIA)



State	Experiment	E(5)
2_1+	$-0.14^{+0.22}_{-0.17}$	-0.24
2_2+	$+0.30^{+0.15}_{-0.15}$	+0.17

universitätbonn

Universität zu Köln

bcgs

Bonn-Cologne Graduate School of Physics and Astronomy

Funded by the German Excellence Initiative

Bonn-Cologne Graduate School of Physics and Astronomy

- invites applications for the Master and PhD programme
- details: http://www.gradschool.physics.uni-bonn.de