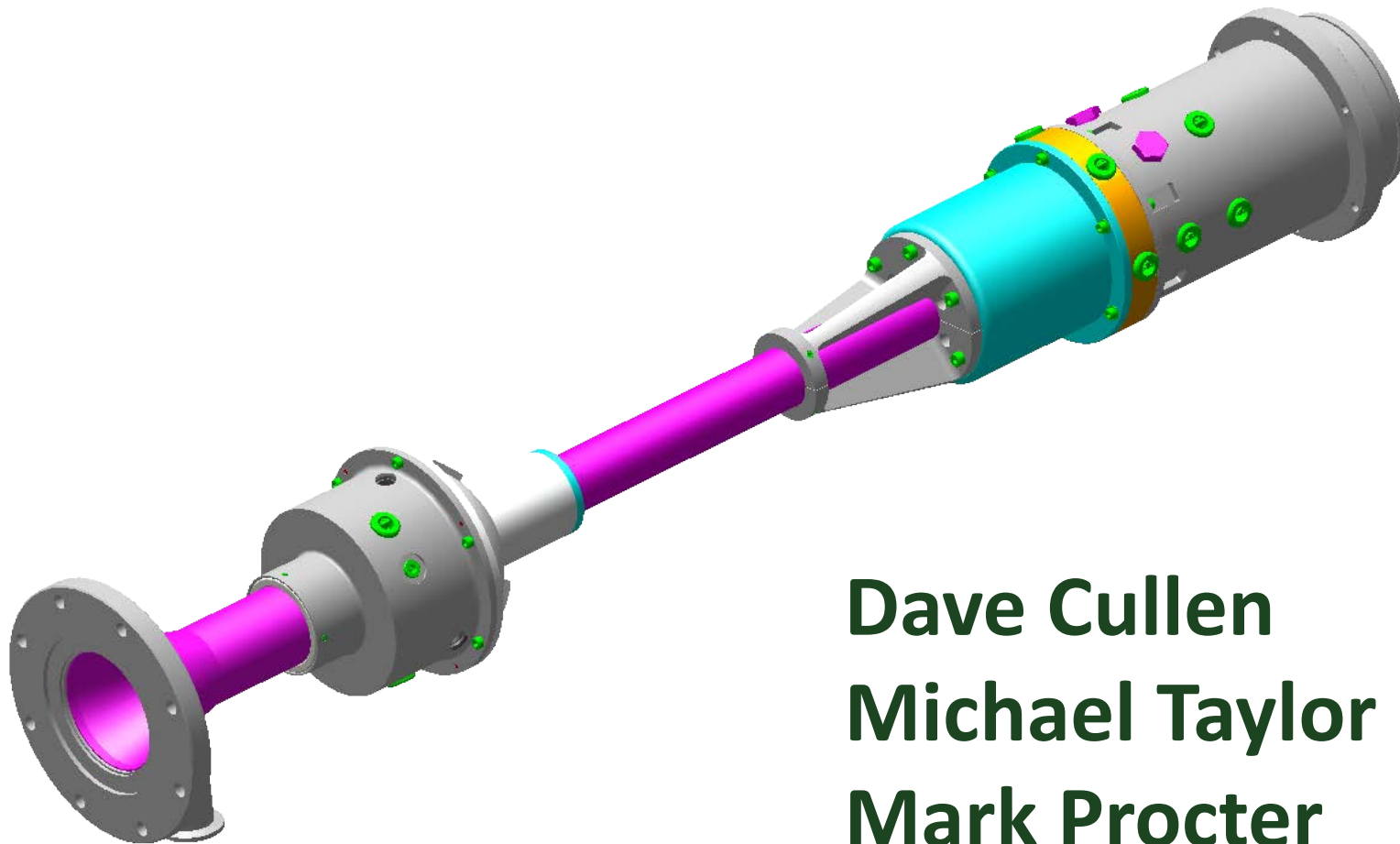


Differential Plunger Measurements of Proton-Unbound Nuclear States (DPUNS)



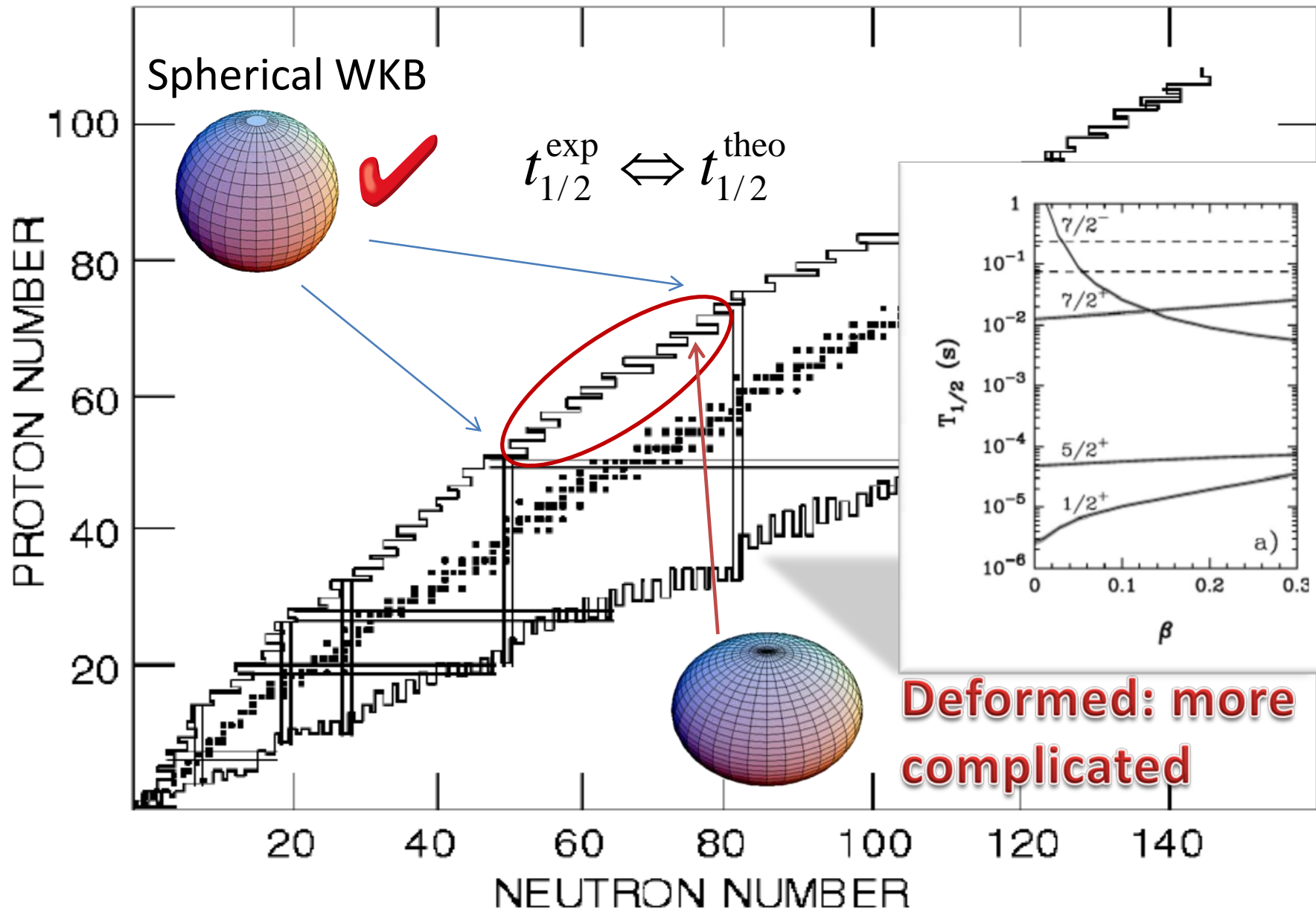
Dave Cullen
Michael Taylor
Mark Procter

1. Motivation

2. Method

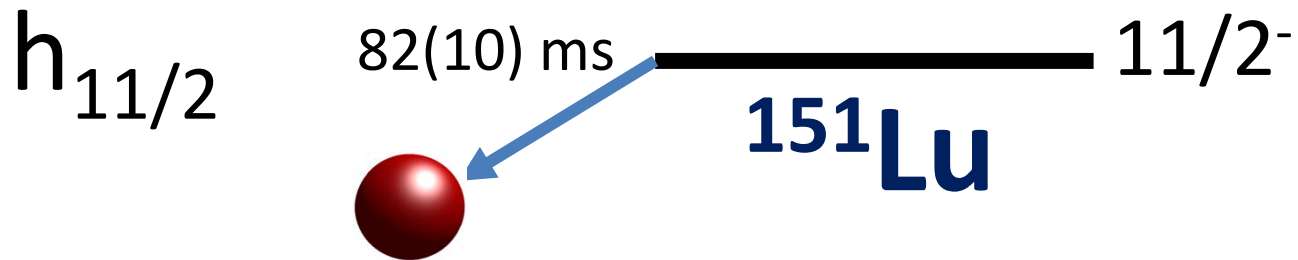
3. Results for ^{151}Lu

Motivation

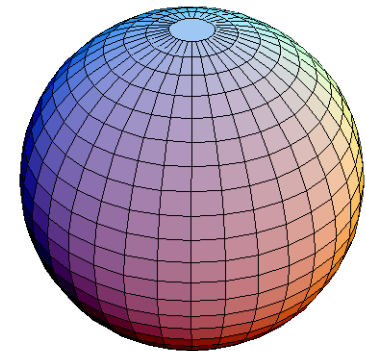


^{151}Lu : The first proton emitter.

- Discovered in 1982

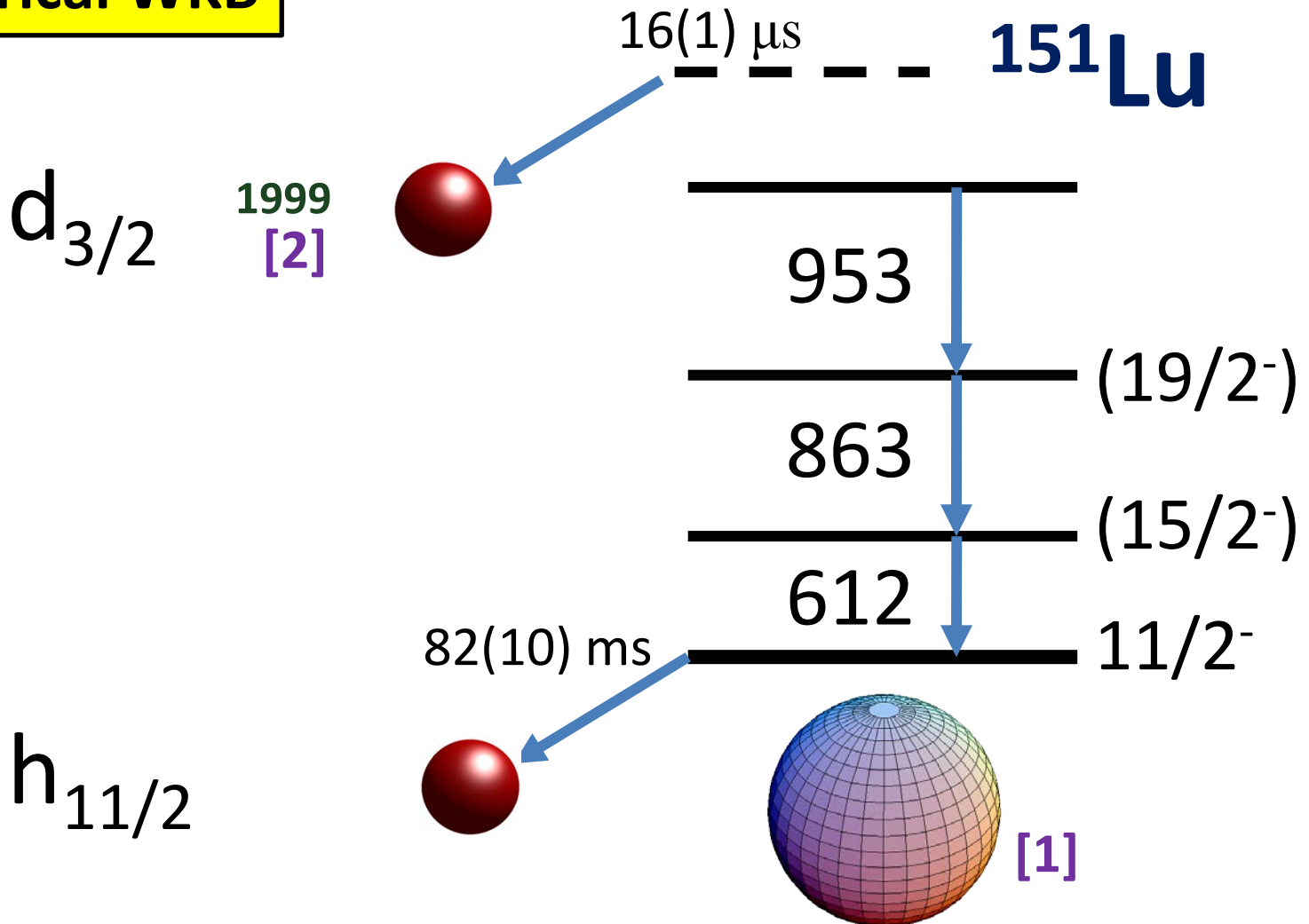


Spherical WKB calculations first used to explain half-life since $N=80$ was close to closed shell.



^{151}Lu : Isomer Proton decay discovered in 1999

Spherical WKB



[1] Hofmann, ZPhysA 305, 111 (1982)

[2] Bingham, PRC 59, R2984 (1999)

^{151}Lu : Spherical or Deformed ?

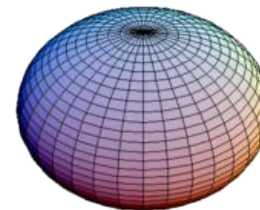
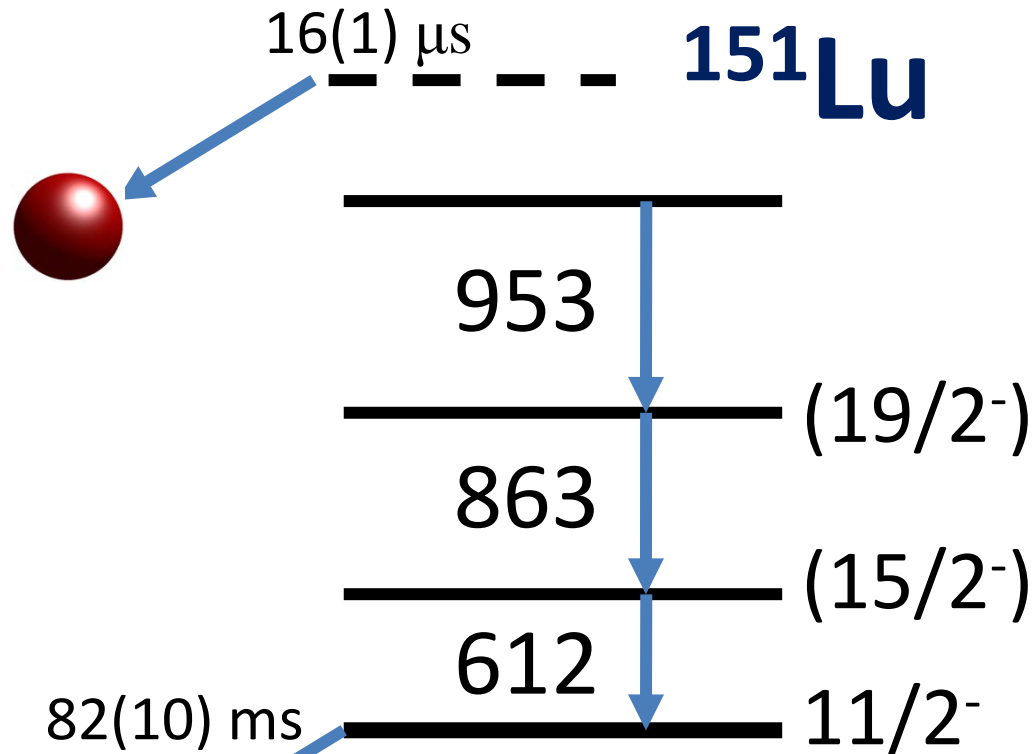
~~Spherical WKB~~

$d_{3/2}$

[2]

Wrong SF's
c.f. experiment

$h_{11/2}$



$\beta_2 = -0.16$

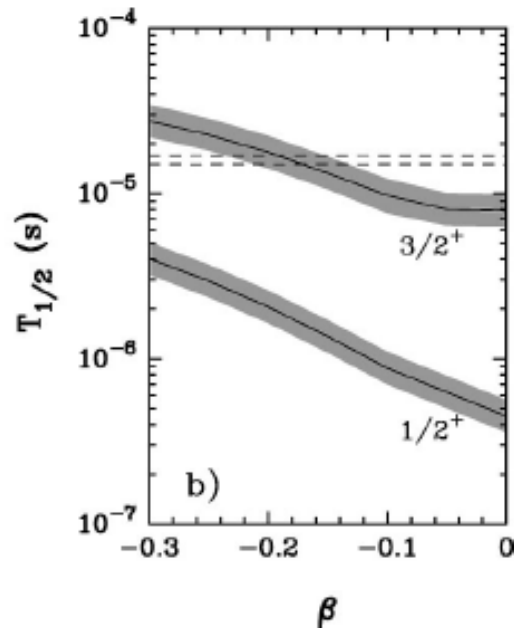
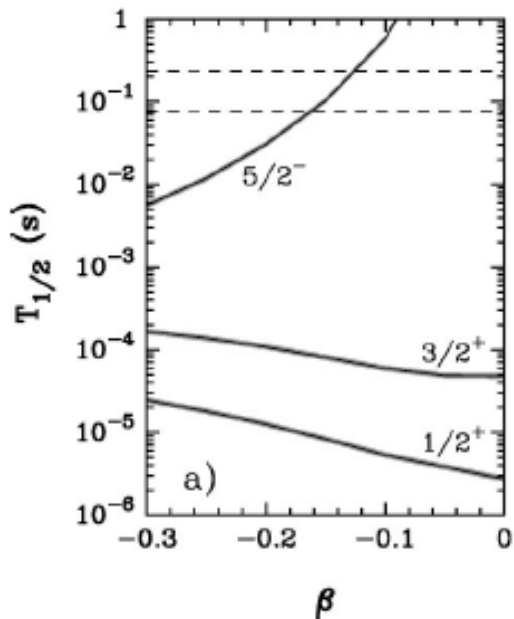
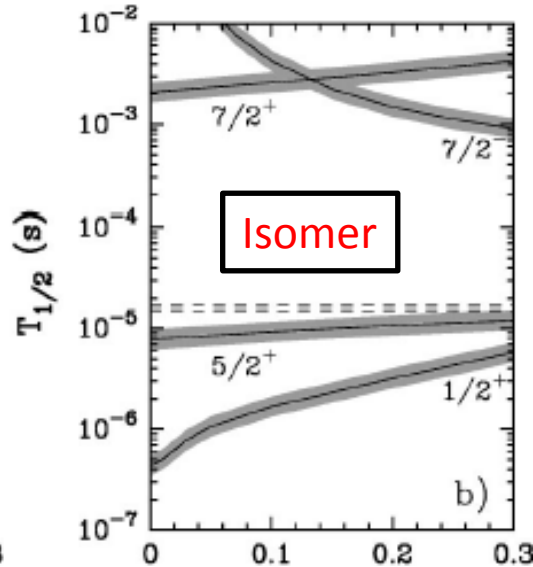
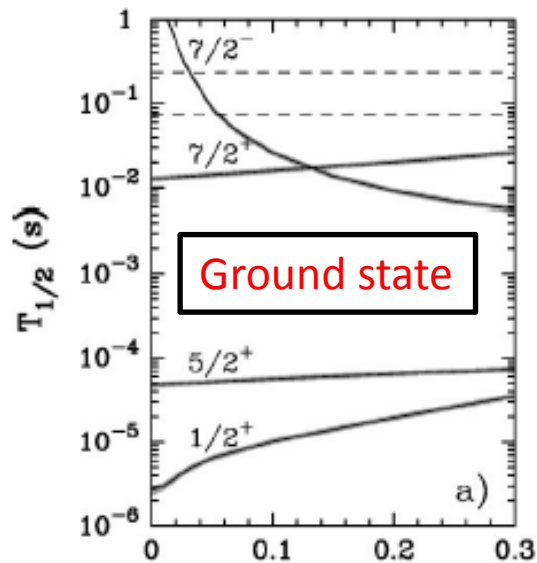
Möller-Nix [3]

Deformed????

[2] Bingham, PRC 59, R2984 (1999)

[3] Möller, Nix, ADNDT 59, 185 (1995)

^{151}Lu Oblate?



• *Ferreira, Maglione*
PRC61, 021304 (2000).

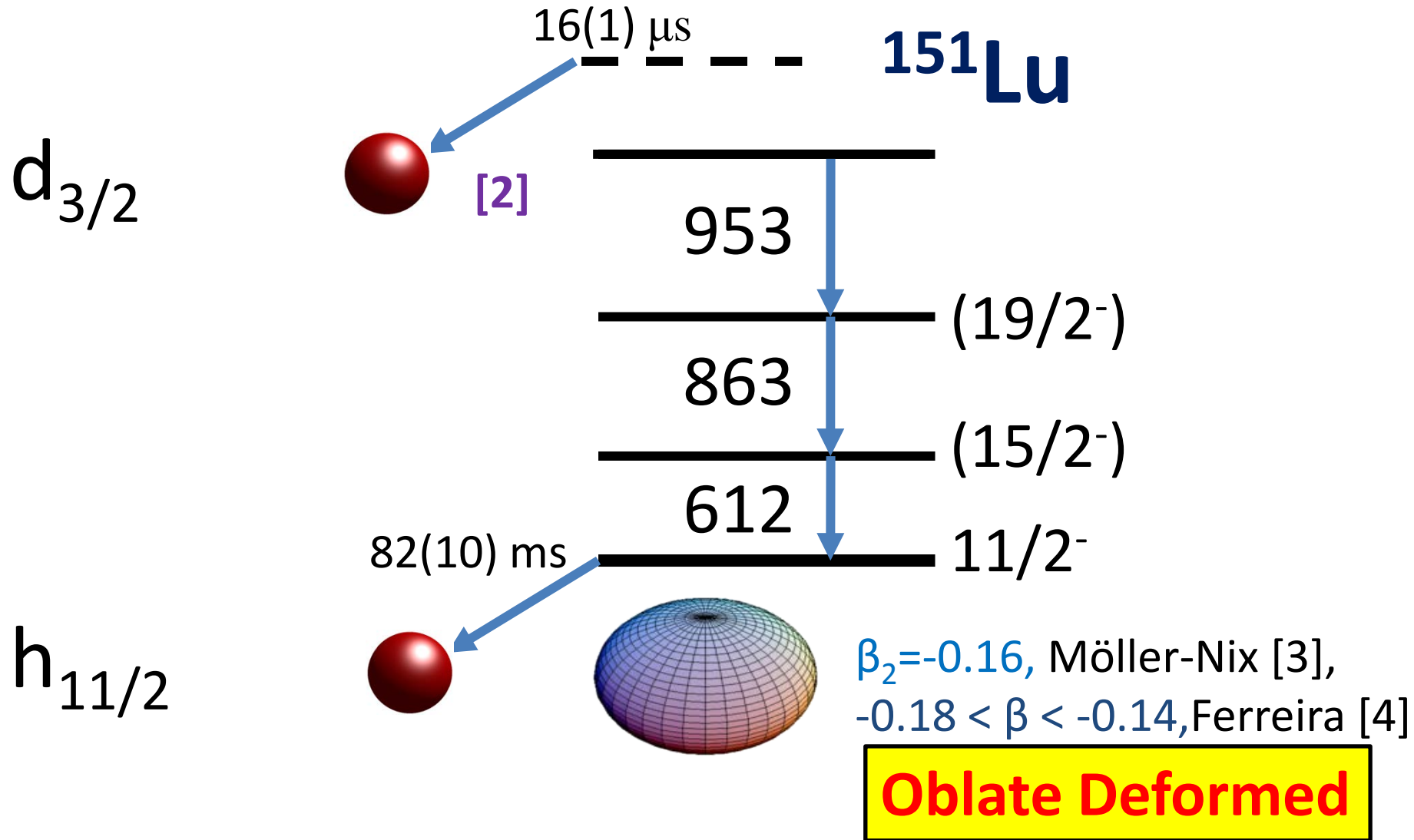
• Deformed Woods-Saxon potential plus spin-orbit.

• Adiabatic calculations:
Parent nucleus wf = particle plus rotor model in strong coupling limit.

• Correct spectroscopic factors and half-lives for proton emission from ground-state and isomer...

$$-0.18 < \beta < -0.14$$

^{151}Lu : Oblate Deformed ?

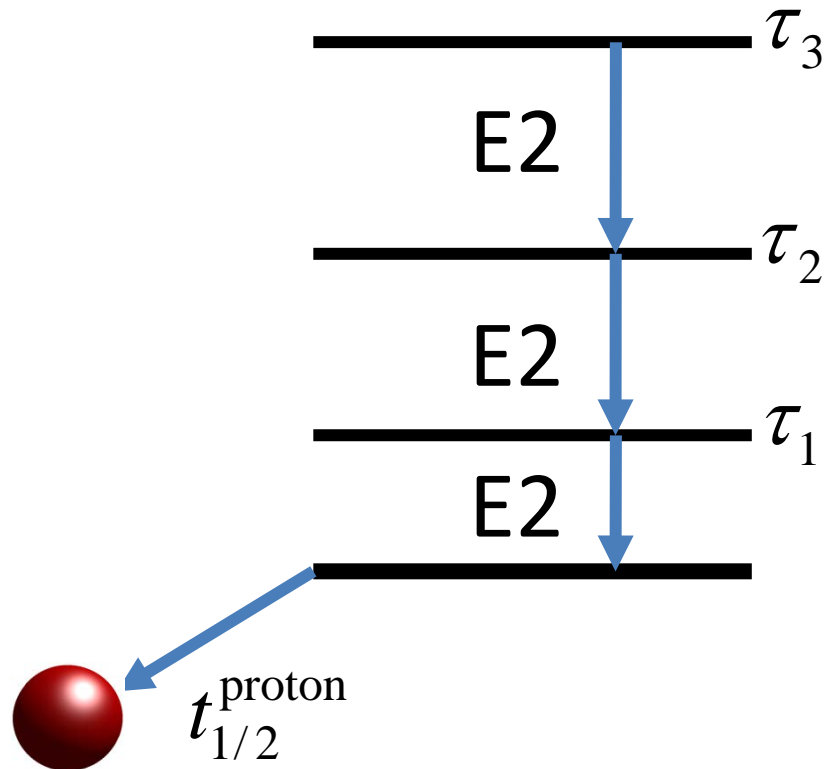


[3] M-N, ADNDT 59, 185 (1995),

[4] Ferreira, Maglione Phys Rev C61, 021304 (2000)

Lifetime \leftrightarrow Deformation

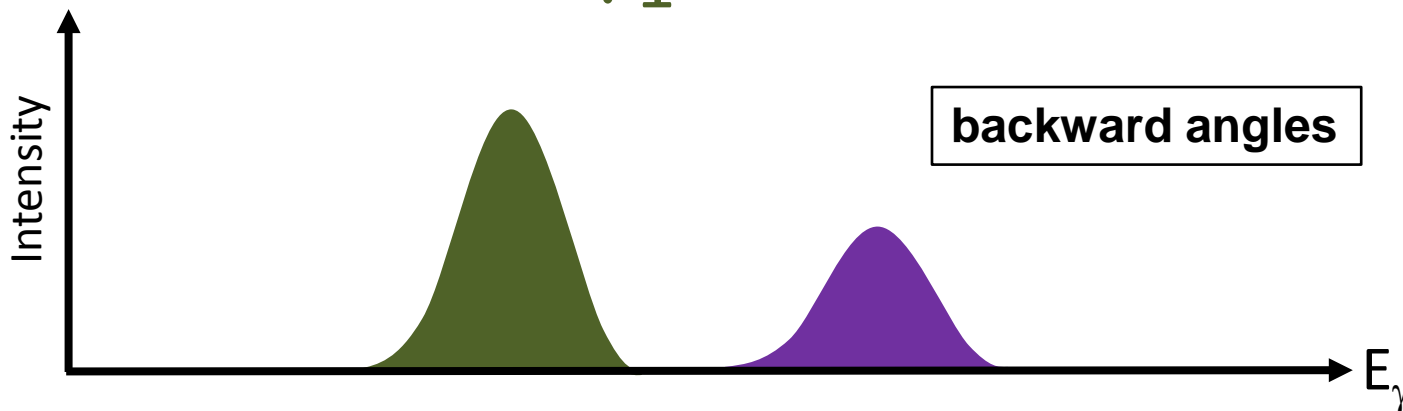
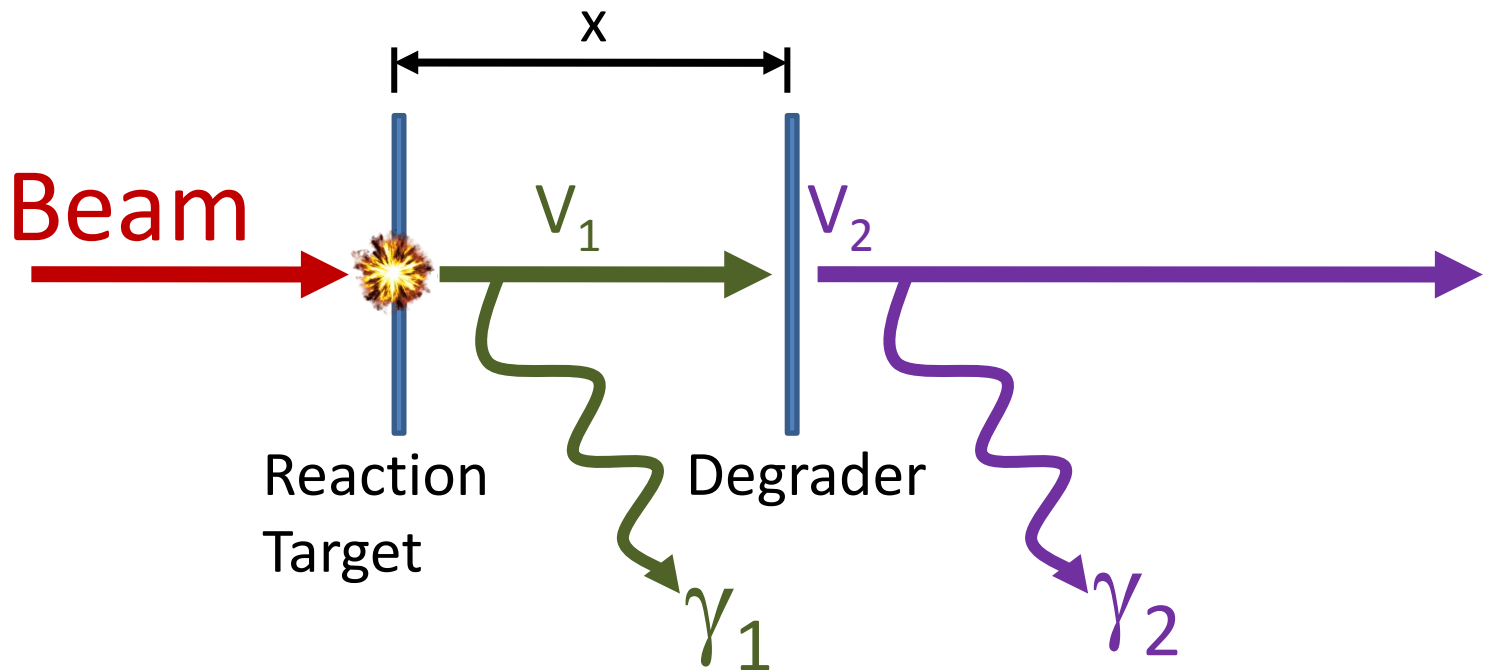
So far: No experimental determination of β



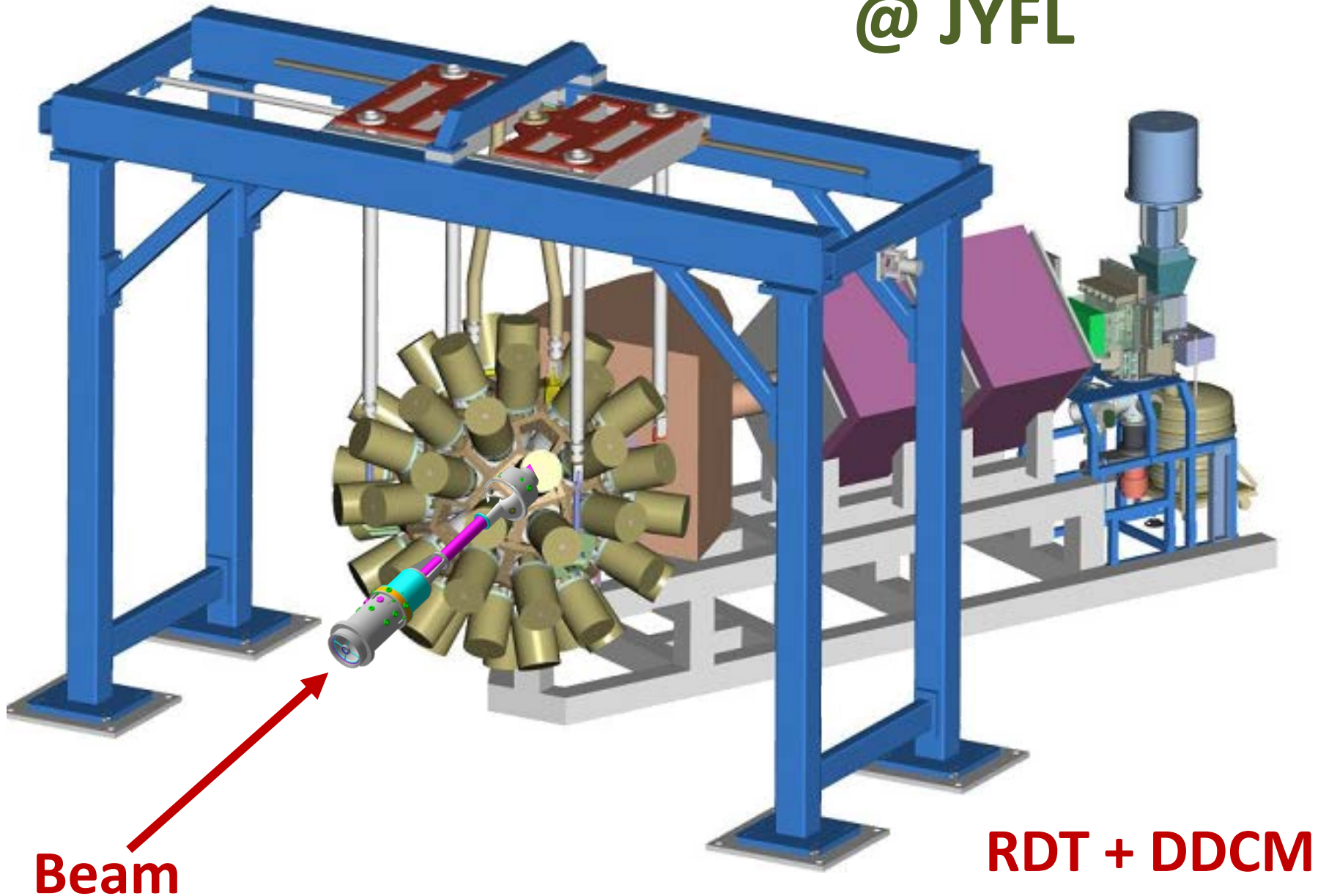
$$\tau \Rightarrow B(E2) \Rightarrow Q_0 \Rightarrow \beta_2$$

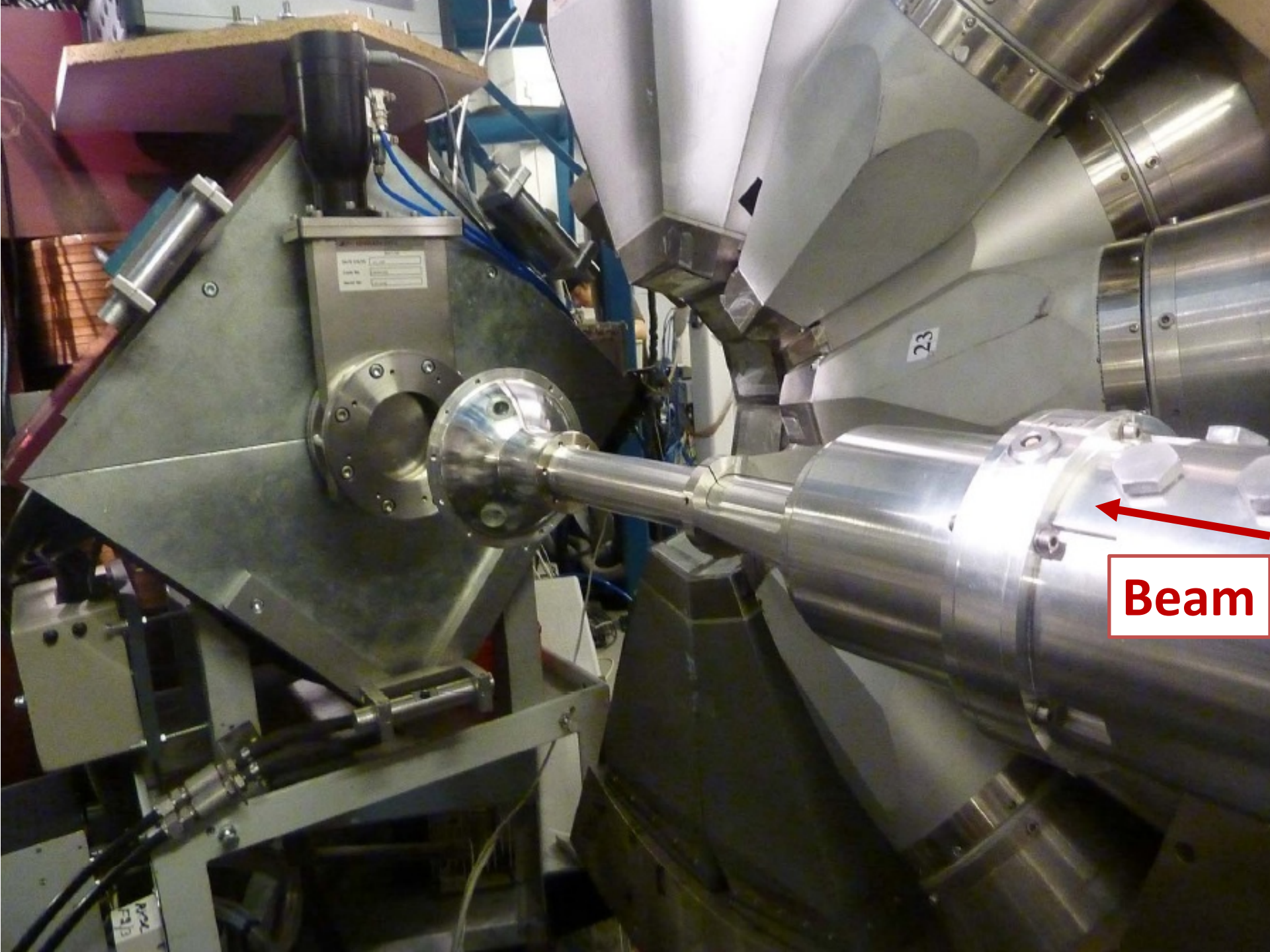
2. Method

Recoil Distance Doppler Shift

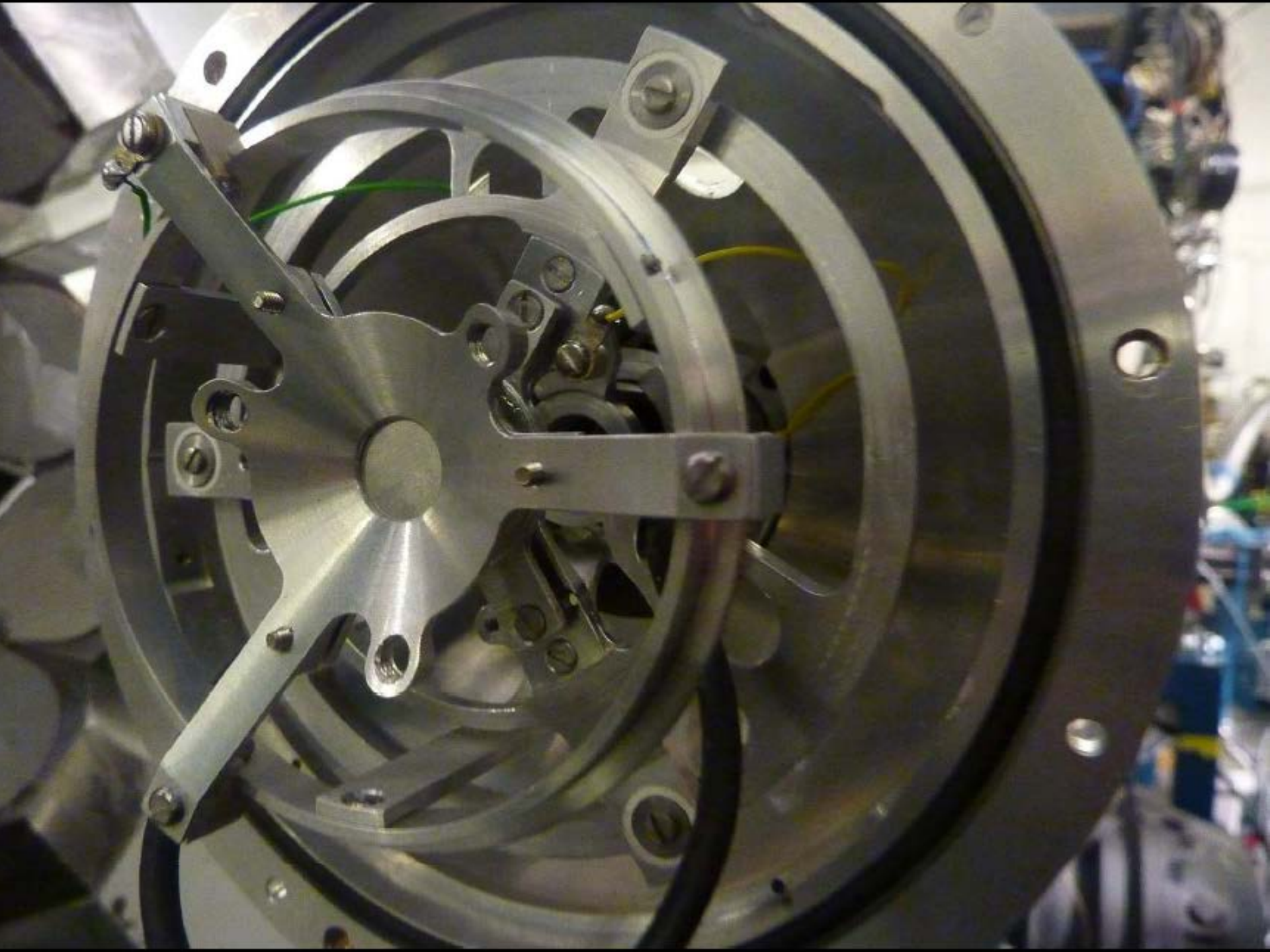


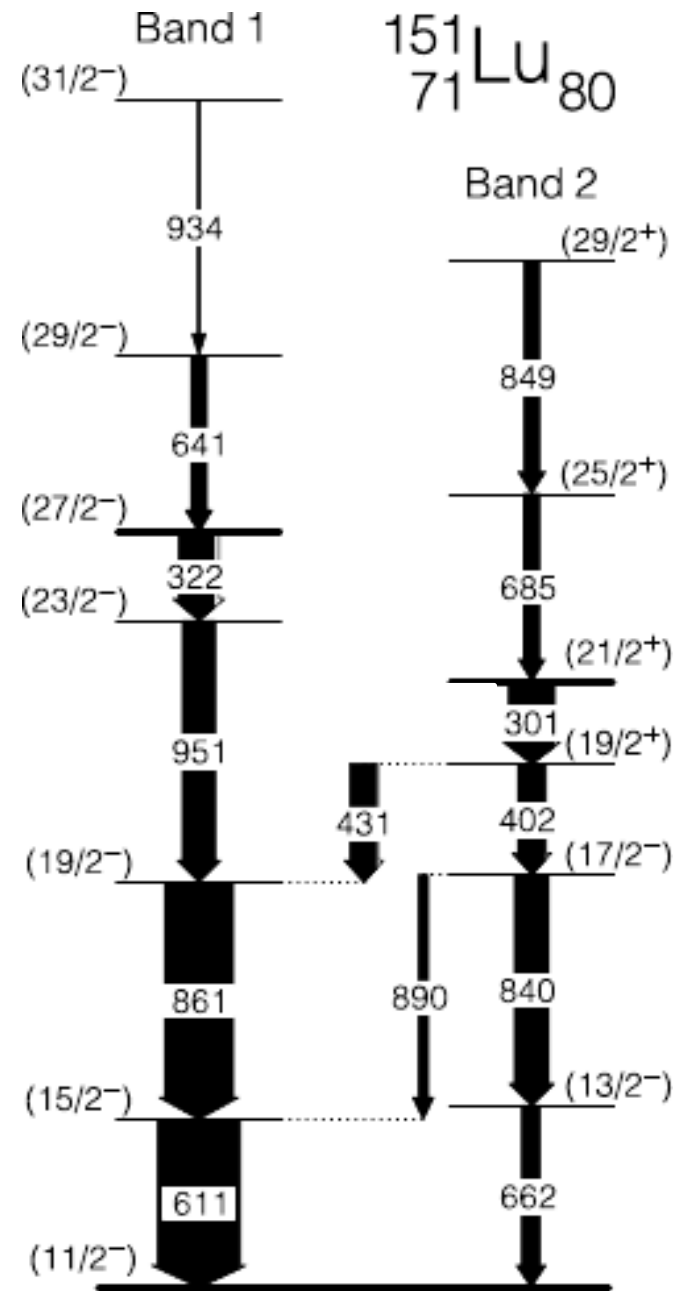
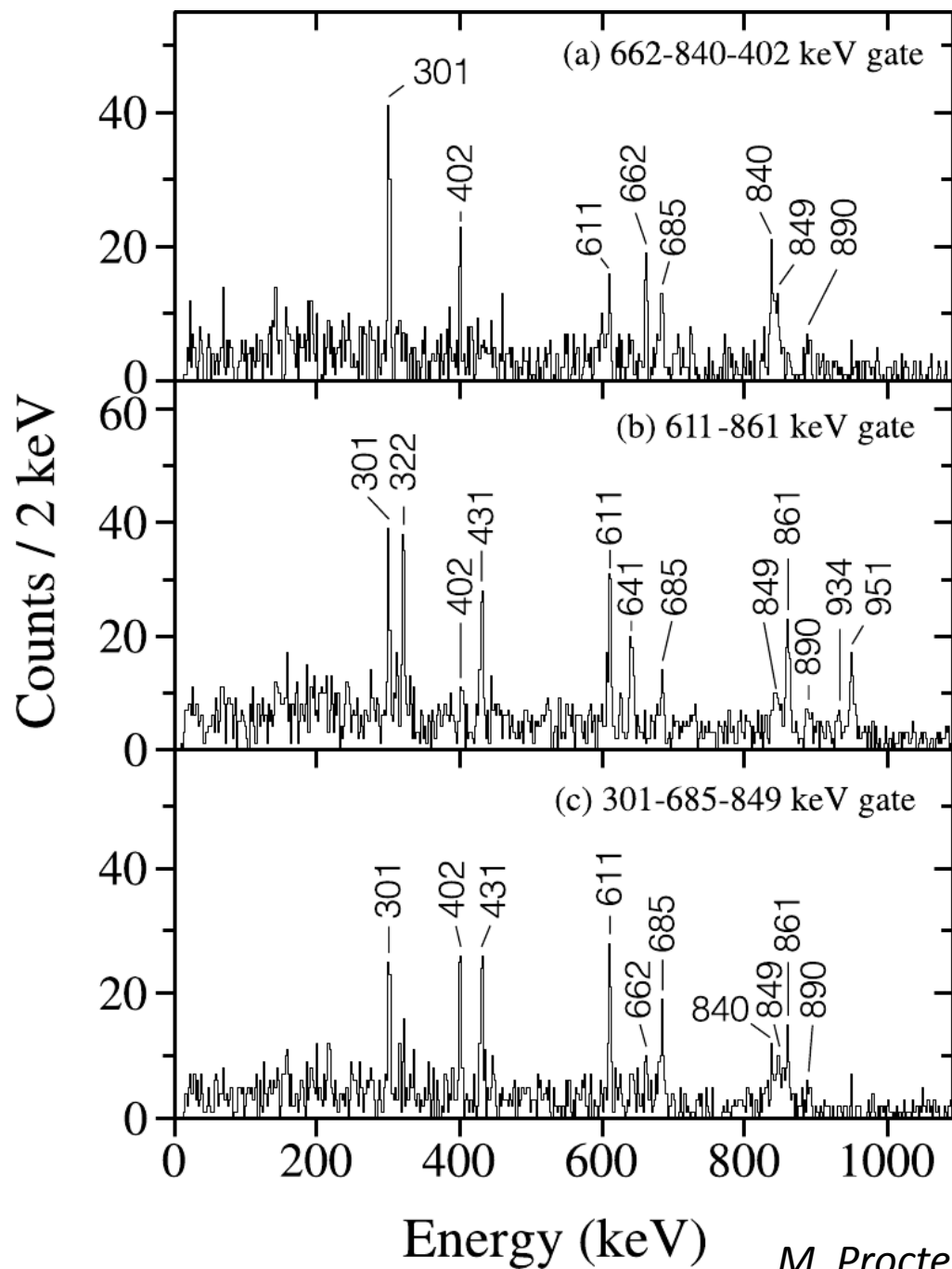
Differential Plunger for Unbound Nuclear States @ JYFL





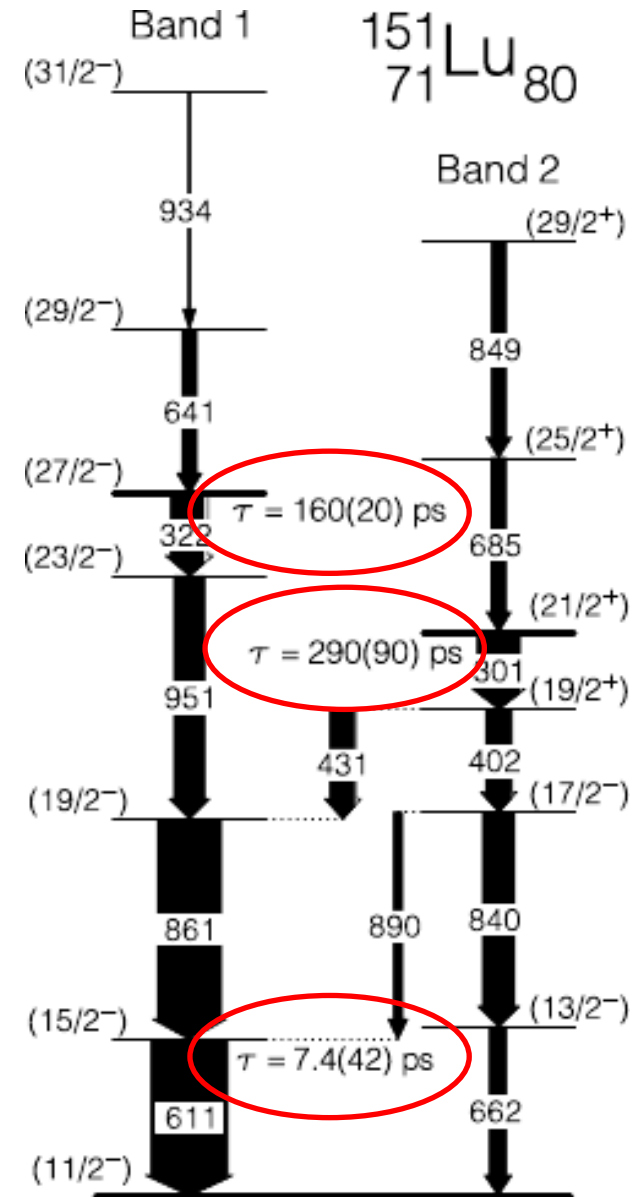
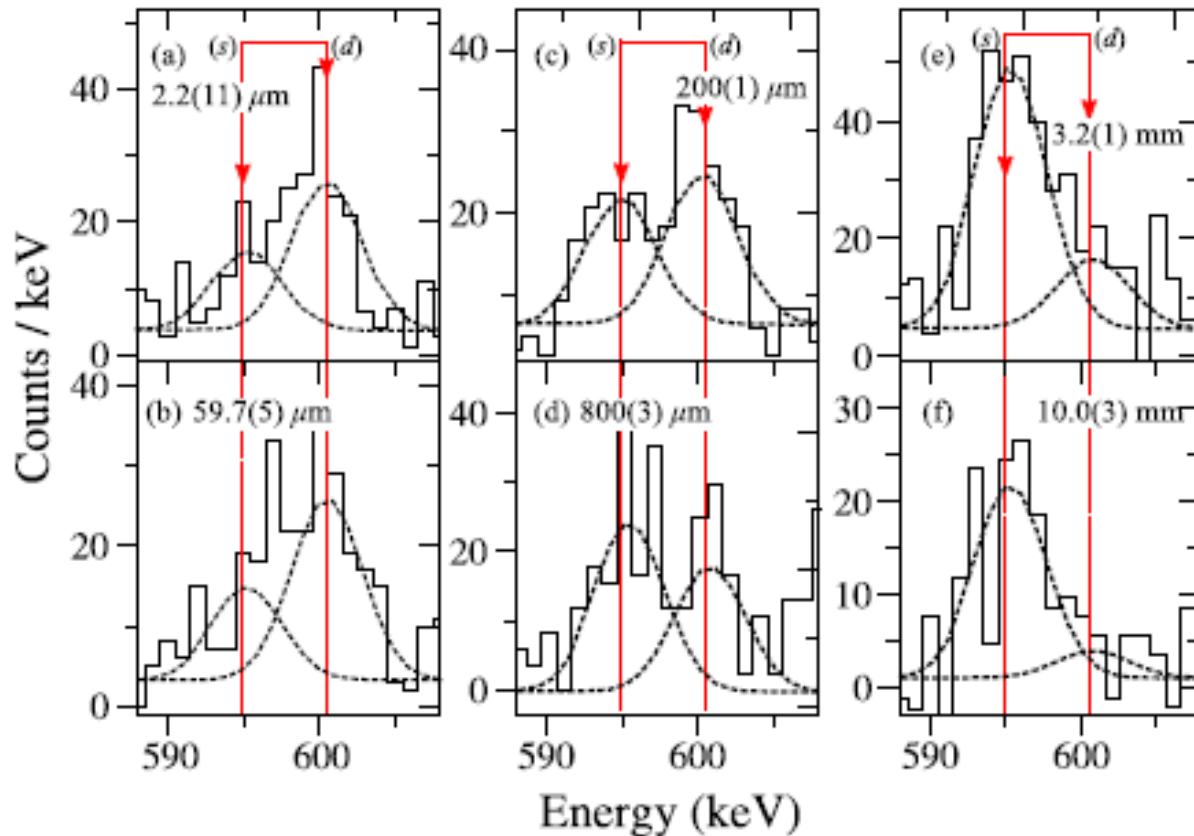
Beam



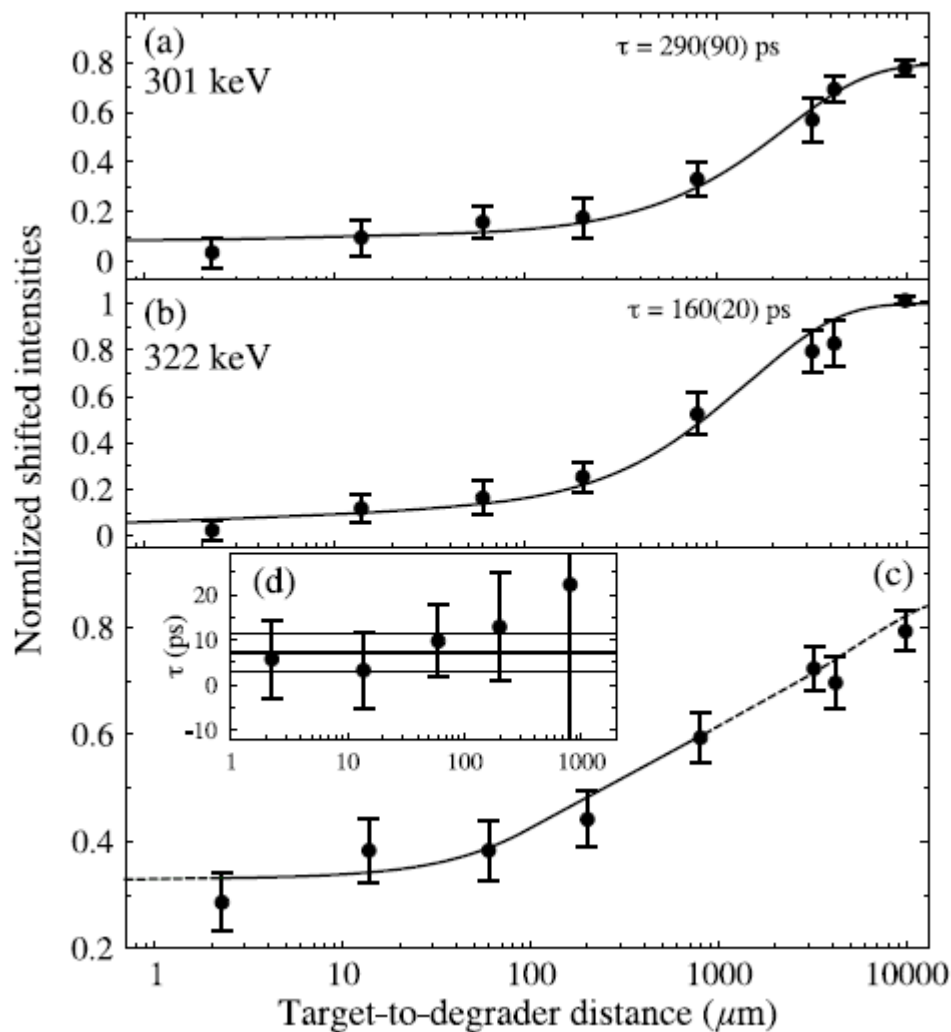


Lifetime analysis

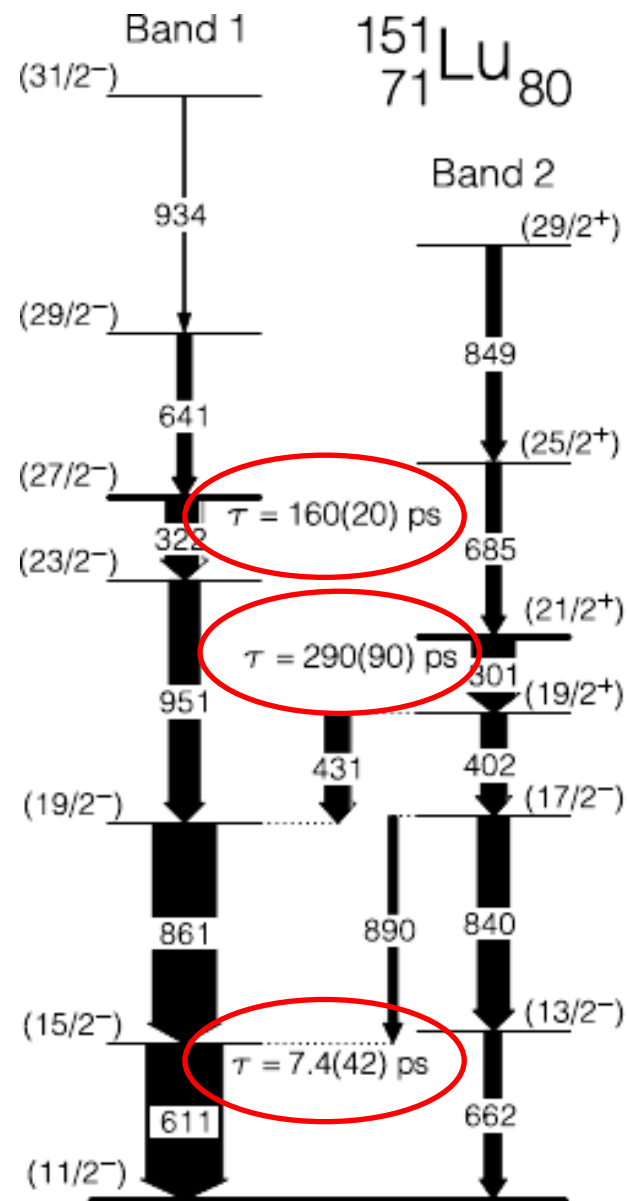
$^{151}\text{Lu}: 15/2^- \rightarrow 11/2^- \quad 138^\circ$



Lifetime analysis



(15/2⁻) has 7.4(42) ps lifetime



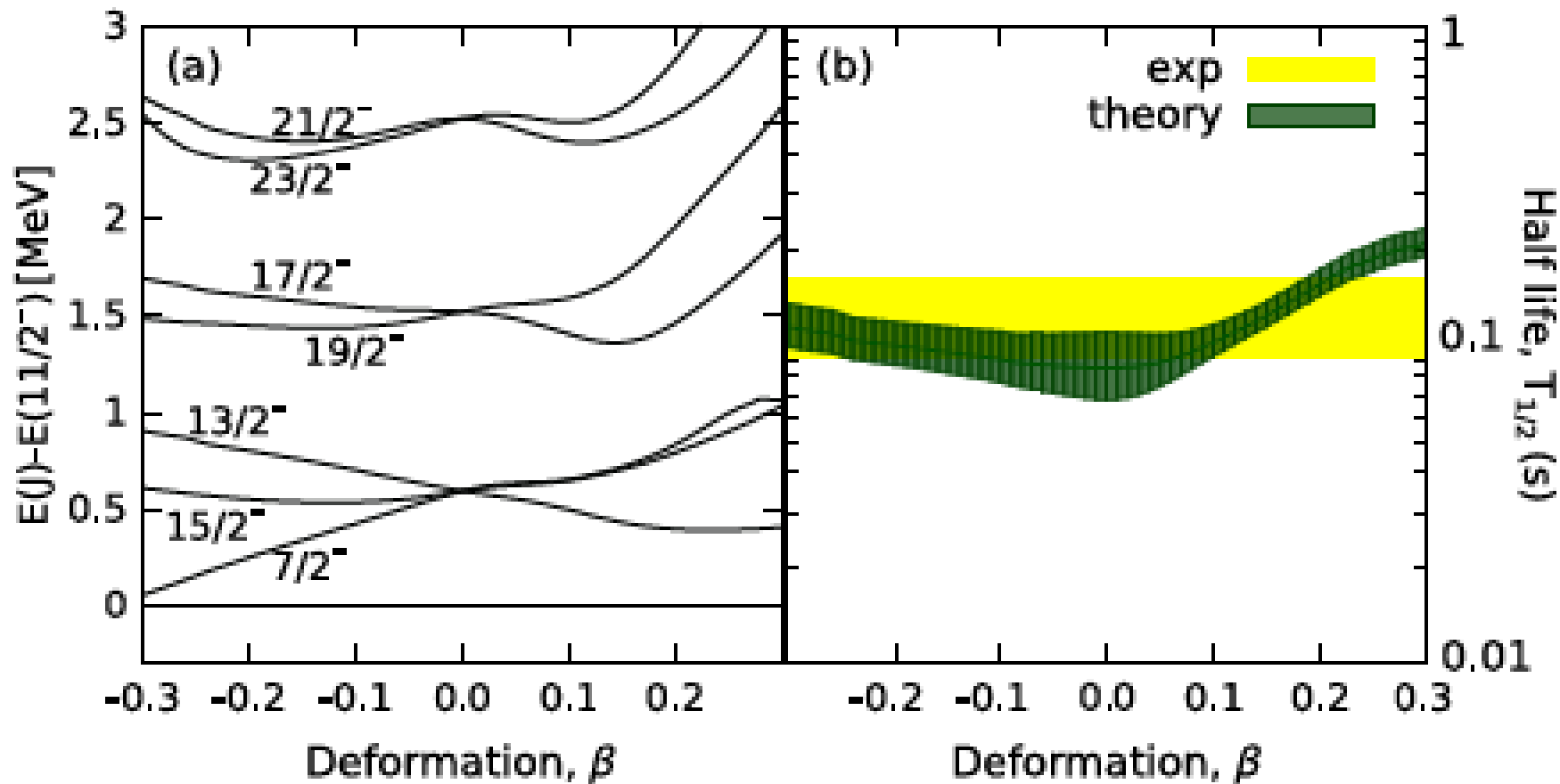
New Deformed calculations:

- Previous calculations PRC 61, 021304 (2000) were *adiabatic* with particle plus rotor model in strong coupling limit.
- New calculations (Ferreira, Maglione to be published):
 1. are *non-adiabatic*; core is allowed to influence valence proton.
 2. calculate lifetime of measured **Electromagnetic** decay from first excited state.

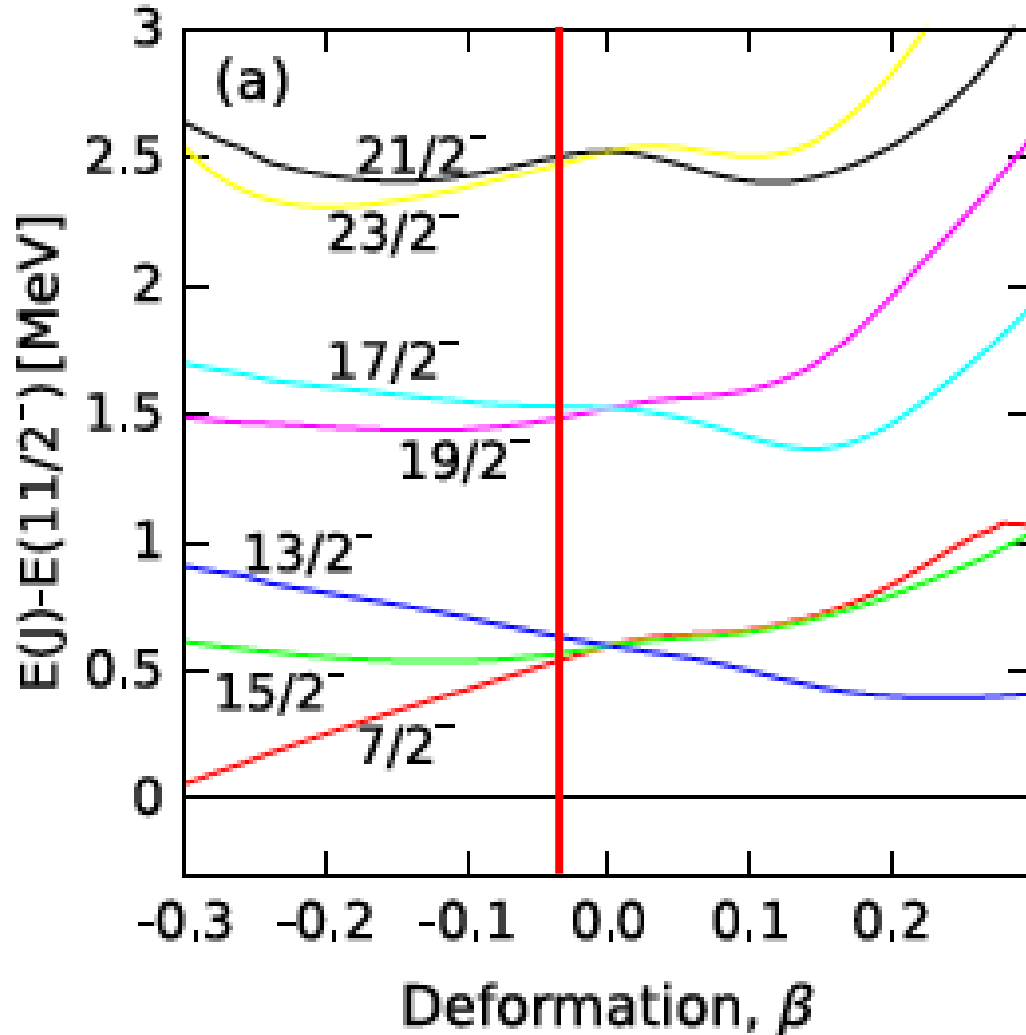
What do we learn from the new non-adiabatic calculations?

1. Level Scheme

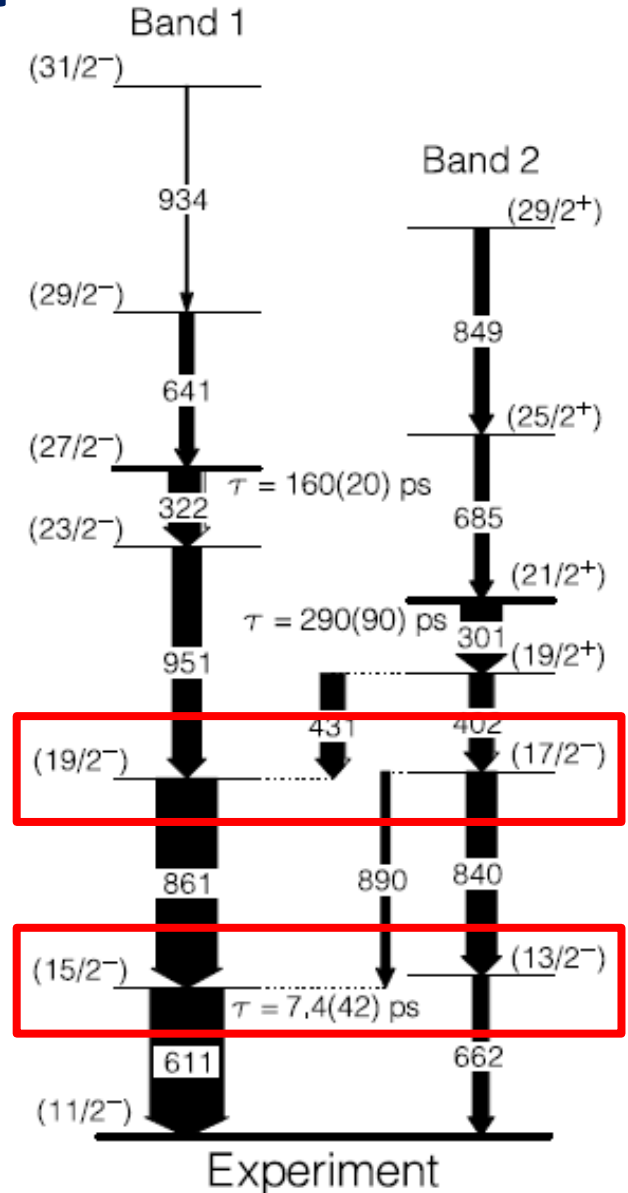
Non-adiabatic Model



Non-adiabatic Model



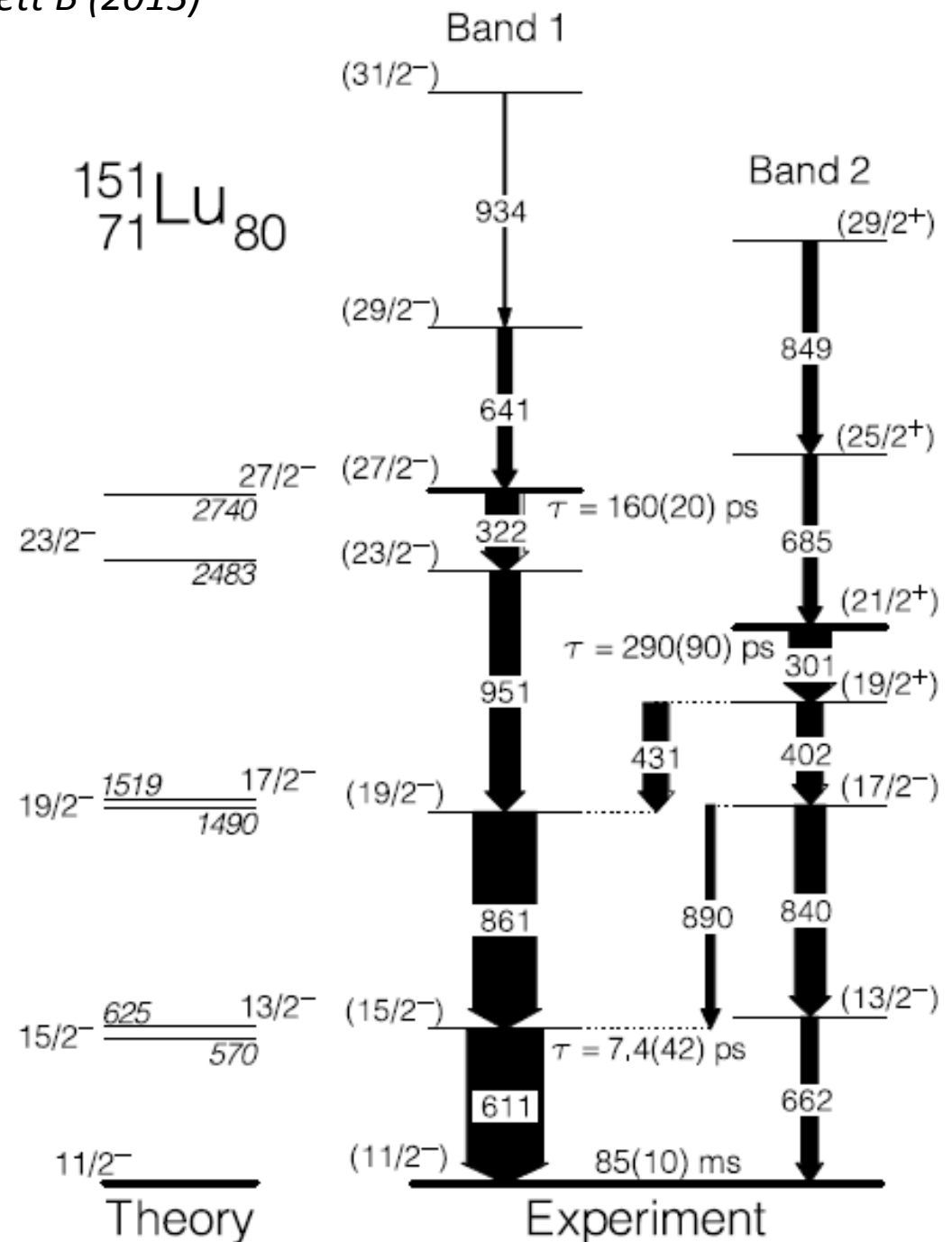
$\beta_2 = -0.03$, but level ordering really tells us must be oblate



$^{151}_{71}\text{Lu}_{80}$

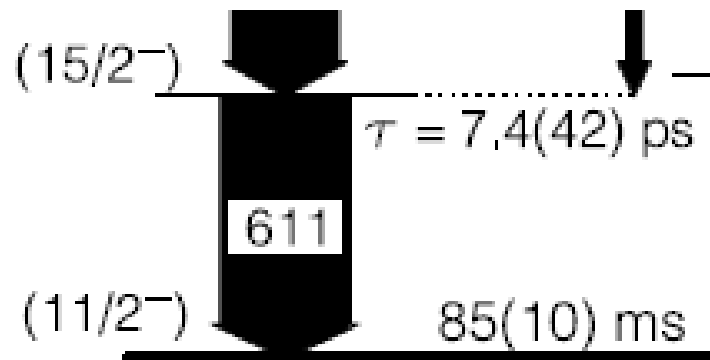
New calculations,
extracted for $\beta_2 = -0.03$
give good agreement
with of experimental
excited states in level
scheme.

Must be oblate.

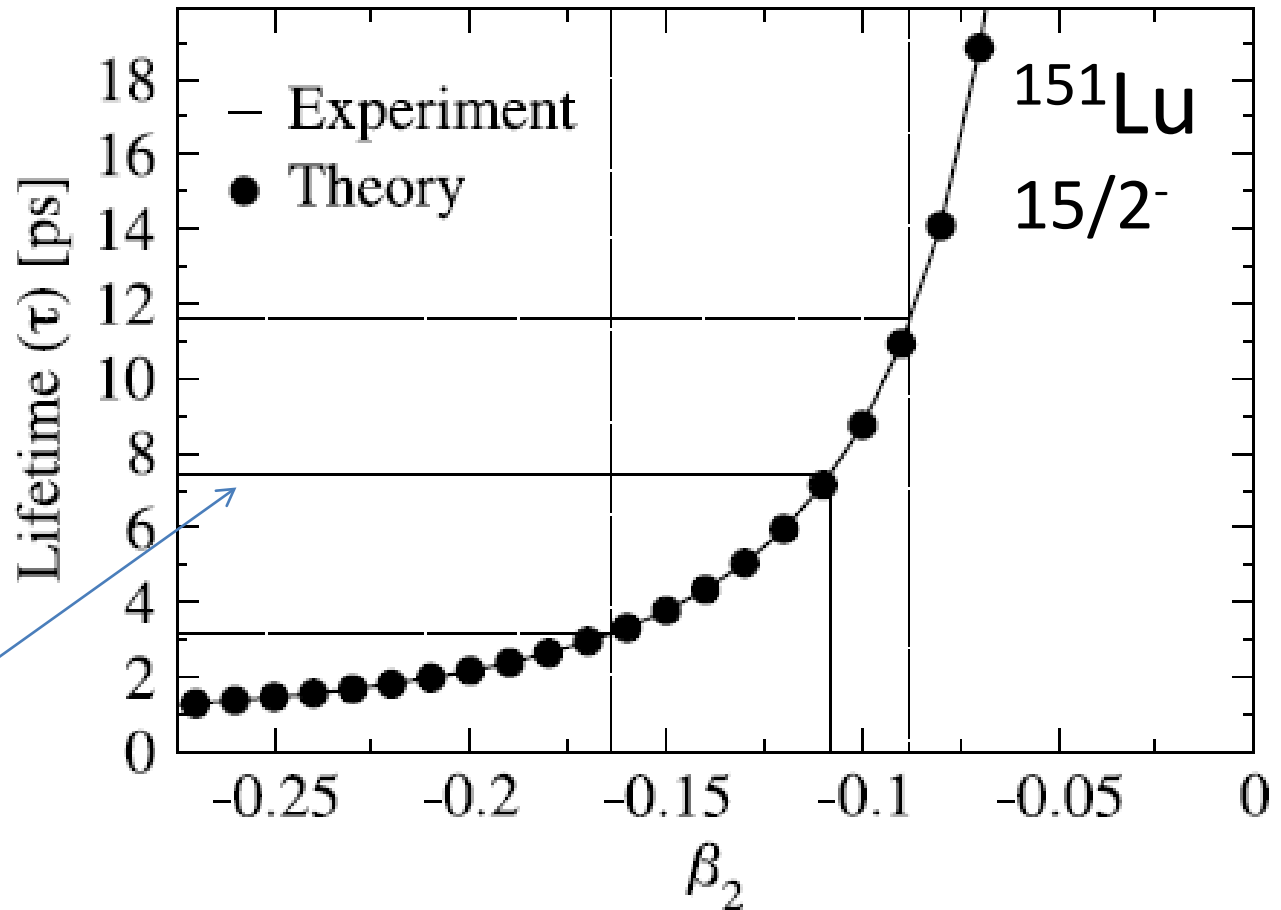


What do we learn from the new non-adiabatic calculations?

2. Electromagnetic Transition Rates



Electromagnetic Transition Rate



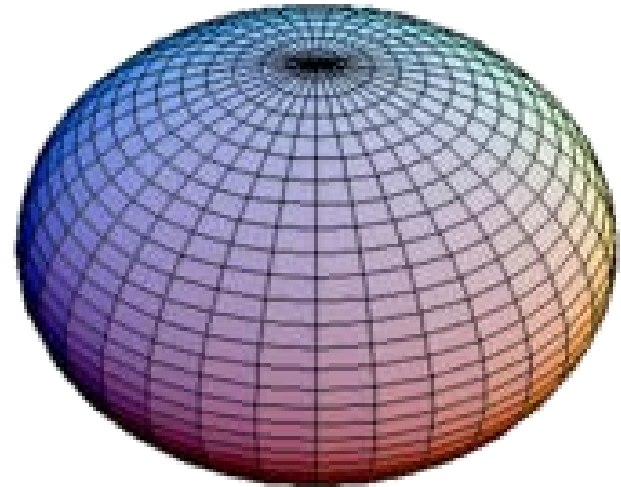
DDCM gave
7.4(42) ps
lifetime for
($15/2^-$)

Final deformation of ^{151}Lu $\beta = -0.11^{+0.02}_{-0.05}$

Conclusions

1. New RDT +DDCM lifetime measurement for first excited state above proton emitter
2. Plus new non-adiabatic theoretical model has allowed :
Sign of deformation determined from excited state level order
Magnitude of deformation extracted from EM transition rate.

**^{151}Lu does seem
indeed to be mildly
oblate, $\beta = -0.11^{+0.02}_{-0.05}$**



Best evidence to date for proton emission from an oblate nucleus?

Collaborators

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