Study of the $B_{4/2}$ anomaly via lifetime measurements in neutron deficient Os isotopes

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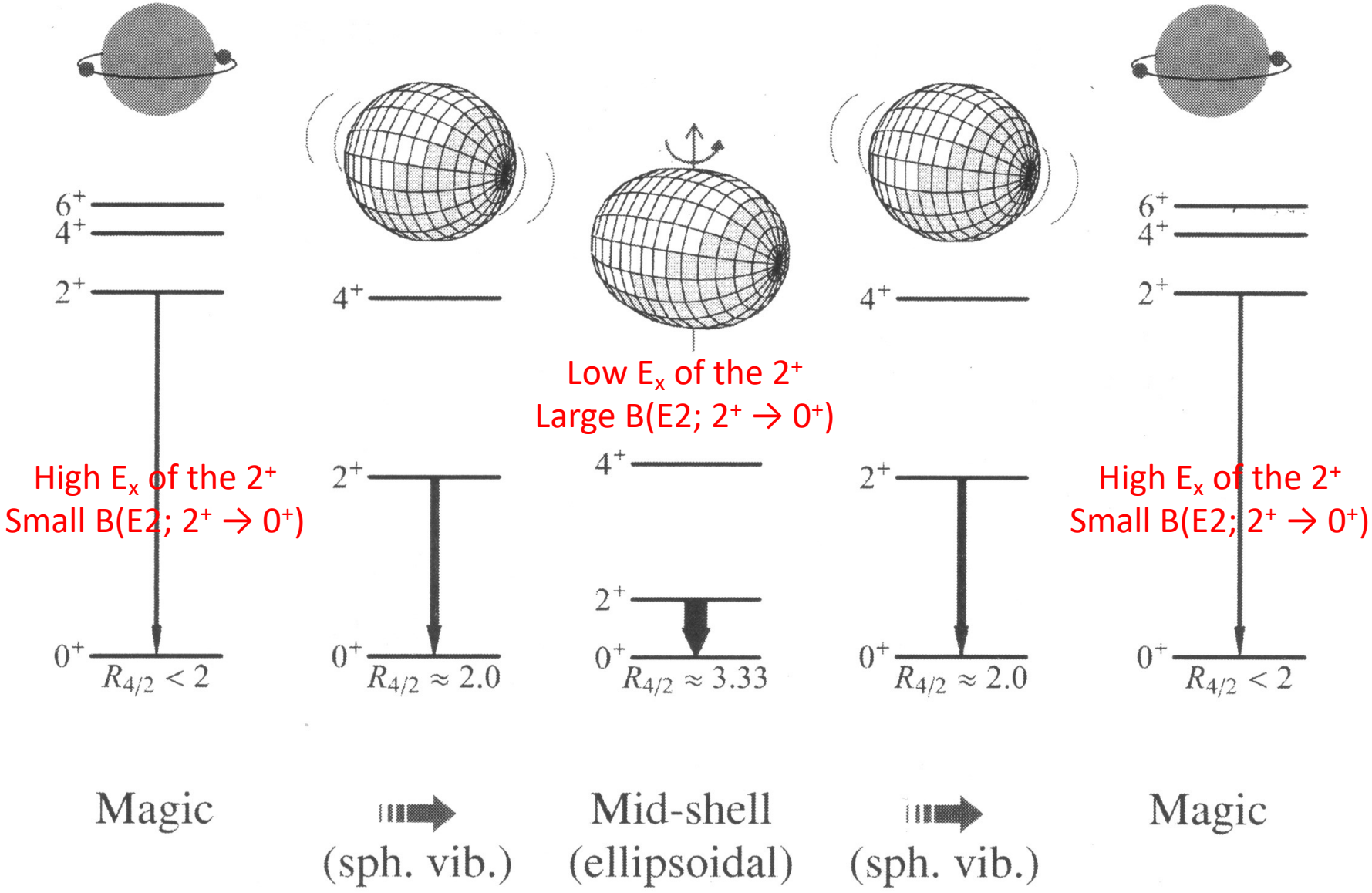


High E_x of the 2^+
Small B(E2; $2^+ \rightarrow 0^+$)

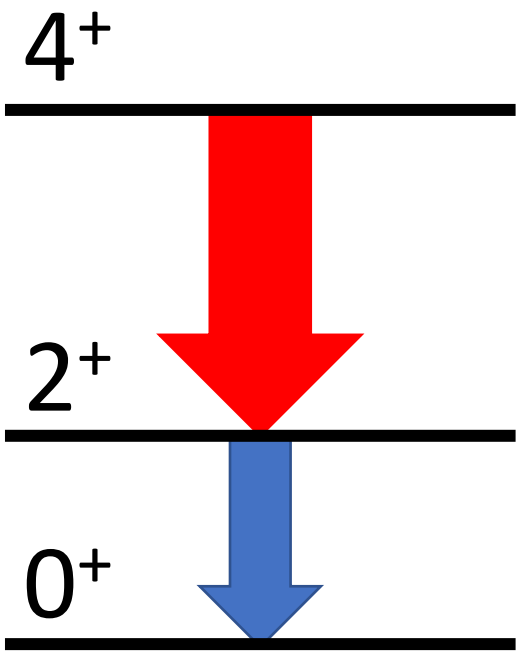
Low E_x of the 2^+
Large B(E2; $2^+ \rightarrow 0^+$)

High E_x of the 2^+
Small B(E2; $2^+ \rightarrow 0^+$)

The $B_{4/2}$ anomaly

$$B_{4/2} = \frac{B(E2;\ 4^+ \rightarrow 2^+)}{B(E2; 2^+ \rightarrow 0^+)} > 1$$

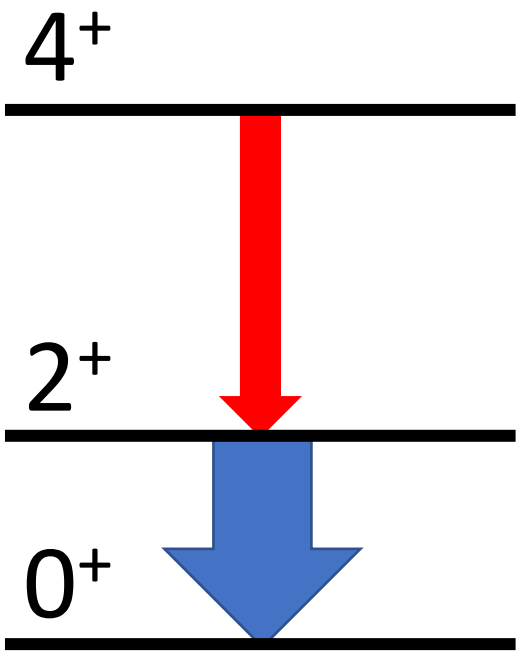
$B_{4/2} > 1$ for collective nuclei



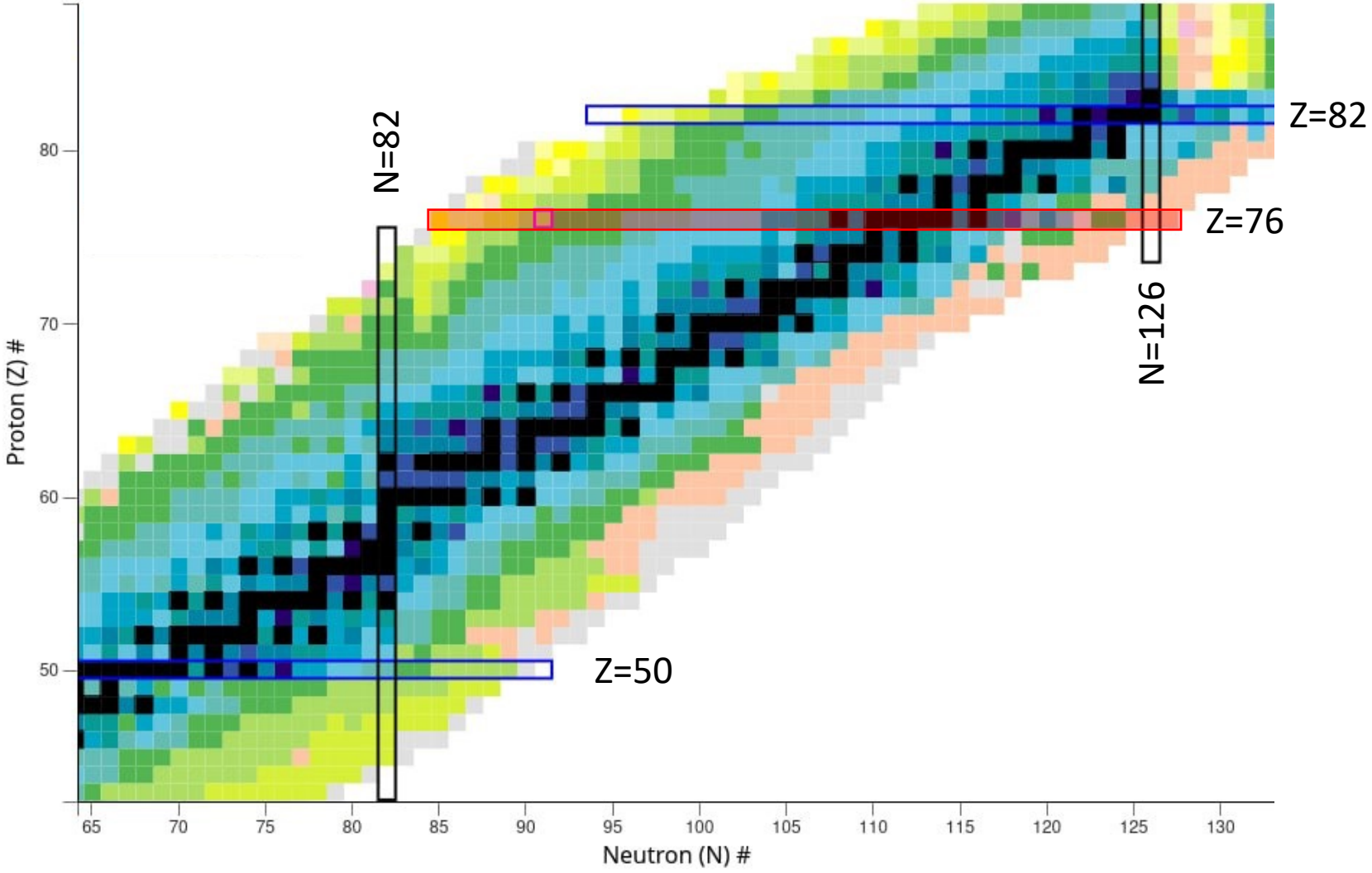
The $B_{4/2}$ anomaly

$B_{4/2} < 1$ in mid-shell nuclei!

Observed in: ^{114}Te, ^{166}W, ^{172}Pt, ^{168,170}Os...

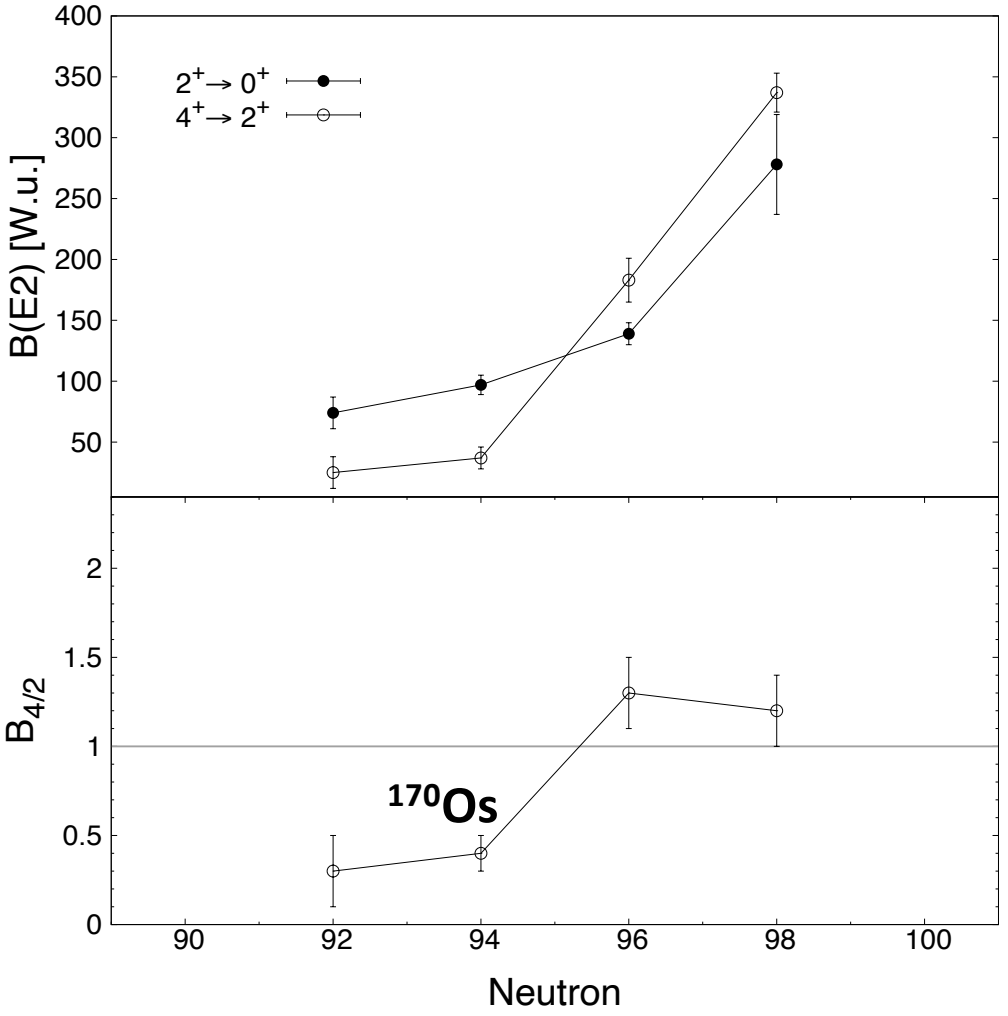


The osmium chain



$B_{4/2}$ anomaly in Os

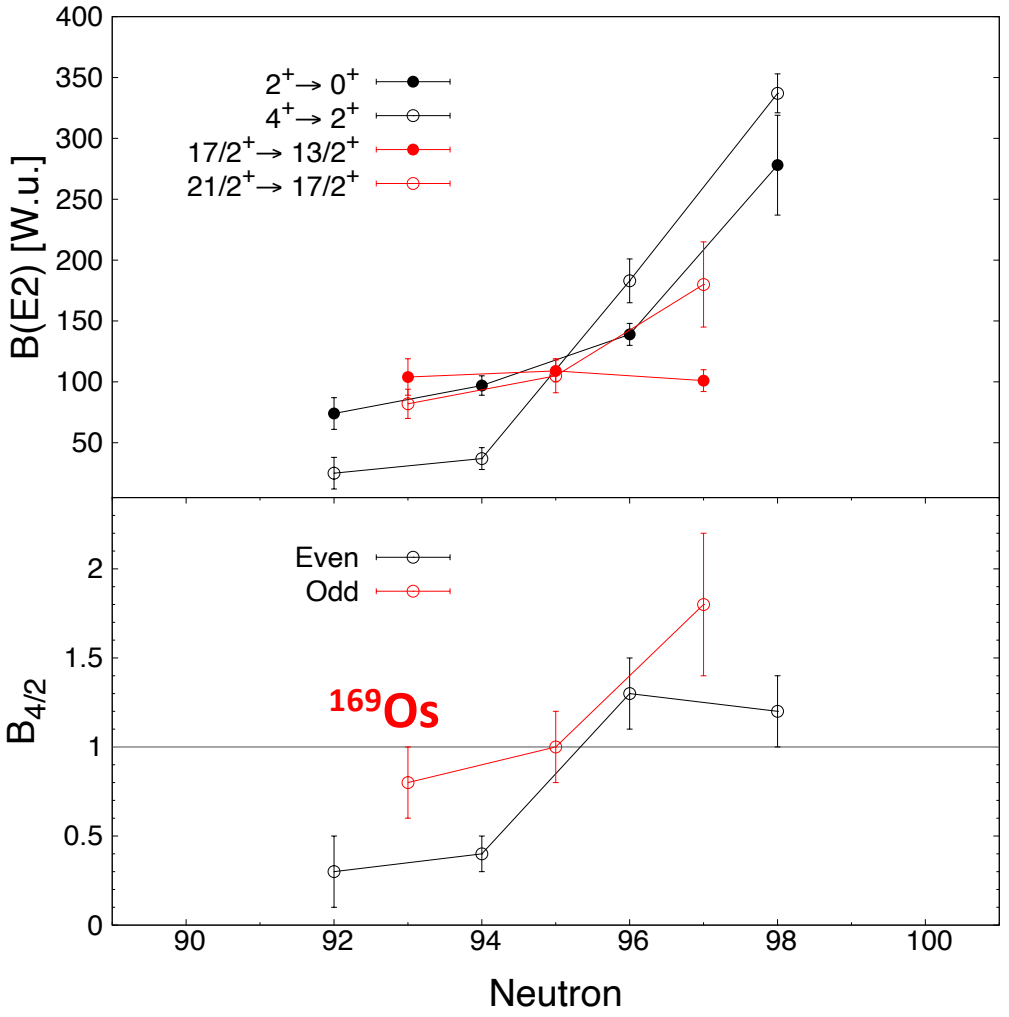
- **Seniority-like scenario;**
- **IBM calculation: triaxial rotor;**
- **No shape change.**



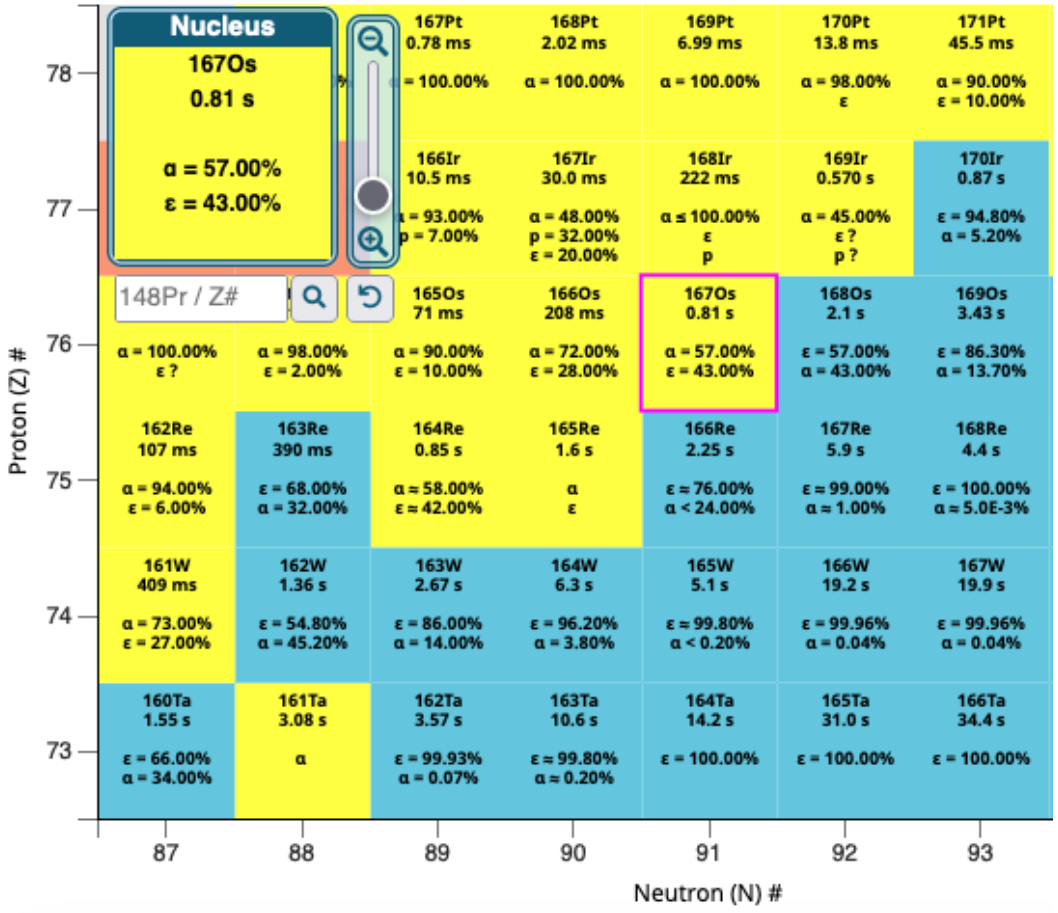
$B_{4/2}$ anomaly in Os

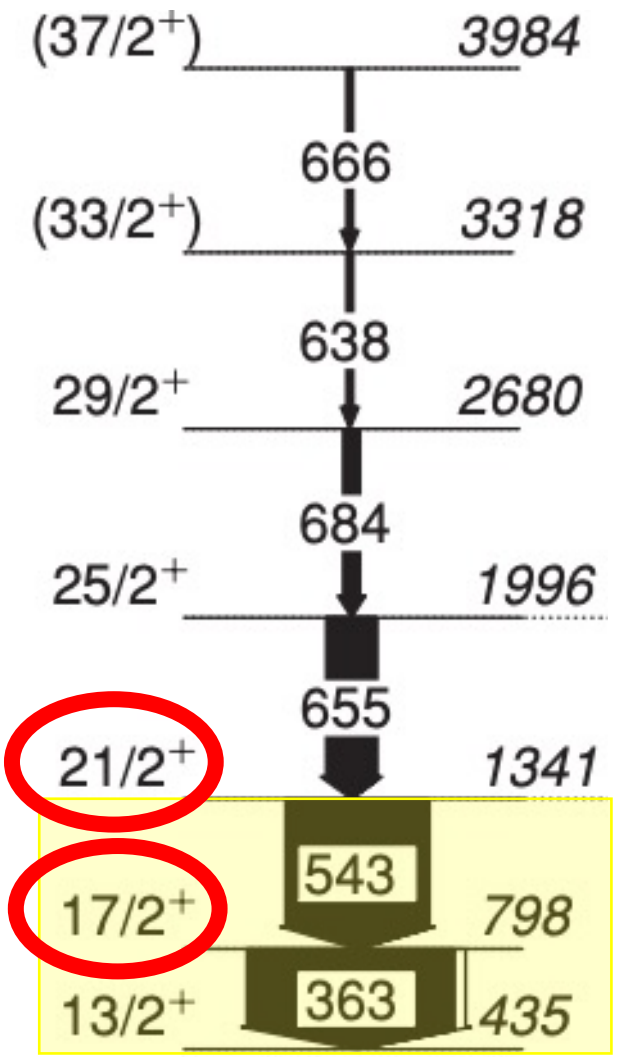
$$B_{4/2} = \frac{B(E2;\ 21/2^+ \rightarrow 17/2^+)}{B(E2; 17/2^+ \rightarrow 13/2^+)}$$

- **Same trend of the even isotopes?**
- **Role of unpaired neutron?**



^{167}Os study case





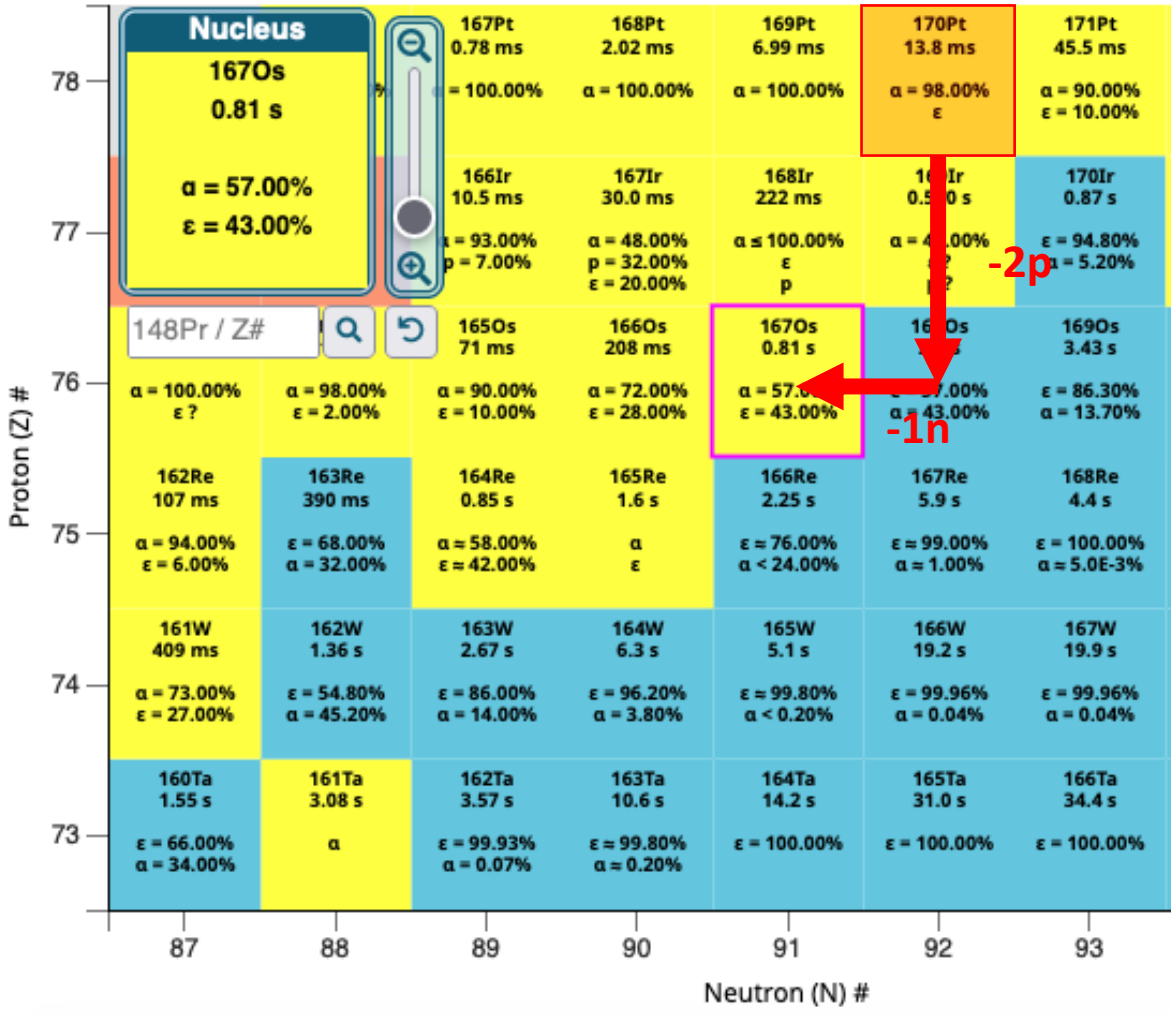
From B(E2) to lifetimes (and back)

$$\lambda(E2) = \frac{1}{\tau} \propto \frac{B(E2;\downarrow)E^5(\alpha+1)}{BR}$$

We measure this…

… to obtain this

Fusion-evaporation reaction



Beam: ^{78}Kr @ 360 MeV

Target: ^{92}Mo, 1.3 mg/cm^2

CN: ^{170}Pt

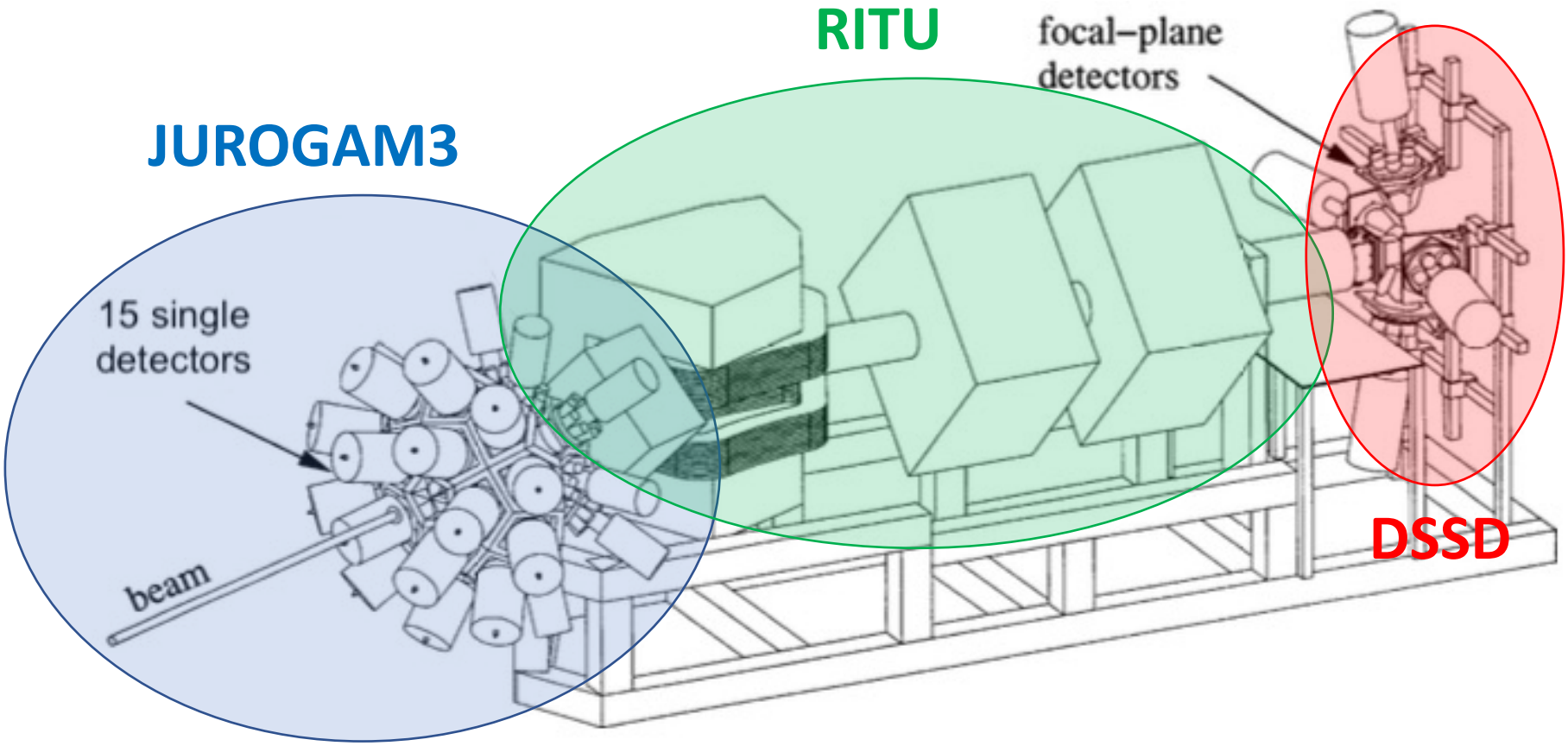
Reaction channel: 2pn

Performed in JYFL (Finland)

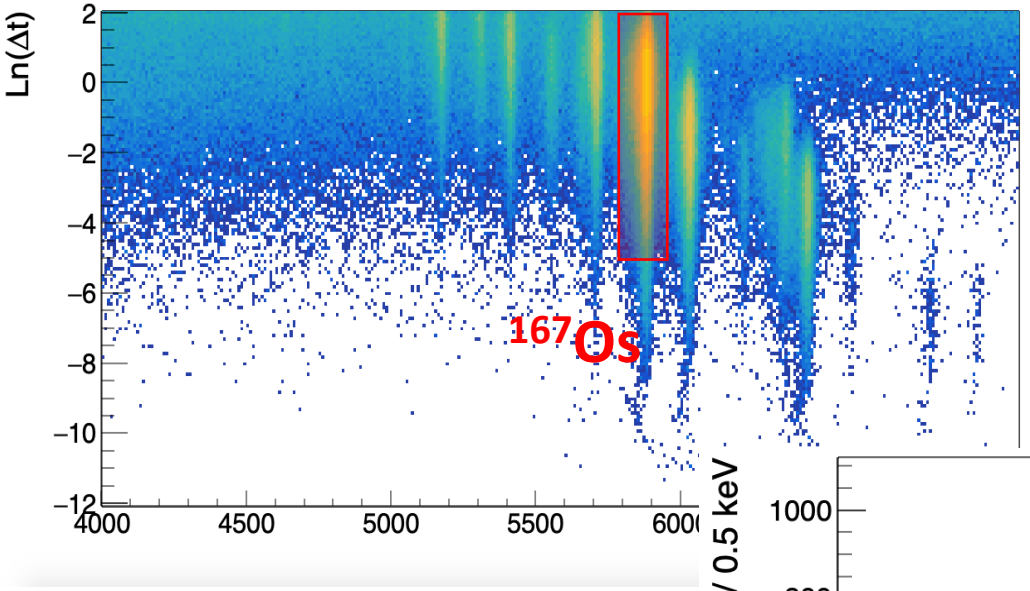
February 2023

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

Experimental setup



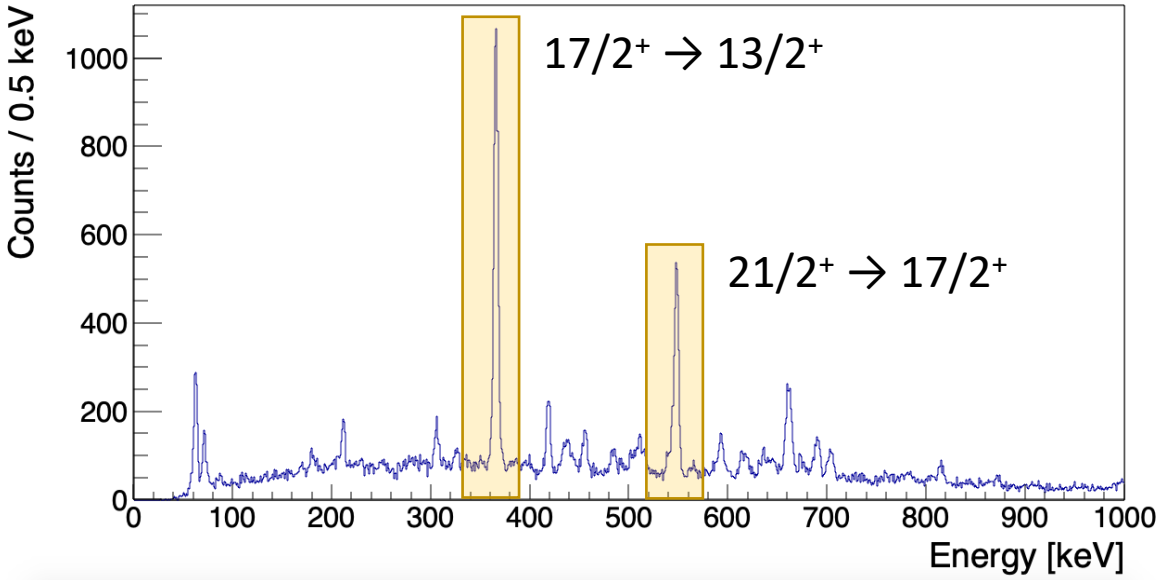
Alpha-decay tagging



DSSD:

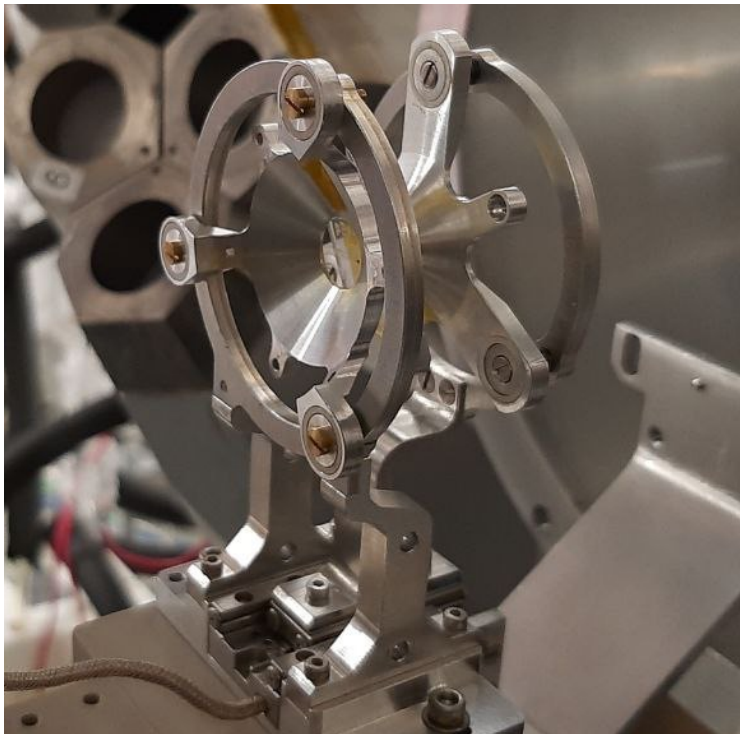
- Detection of reaction product;
- Alpha-decay tagging

Gamma-ray spectrum obtained in coincidence with the alpha-decay at 5839 keV

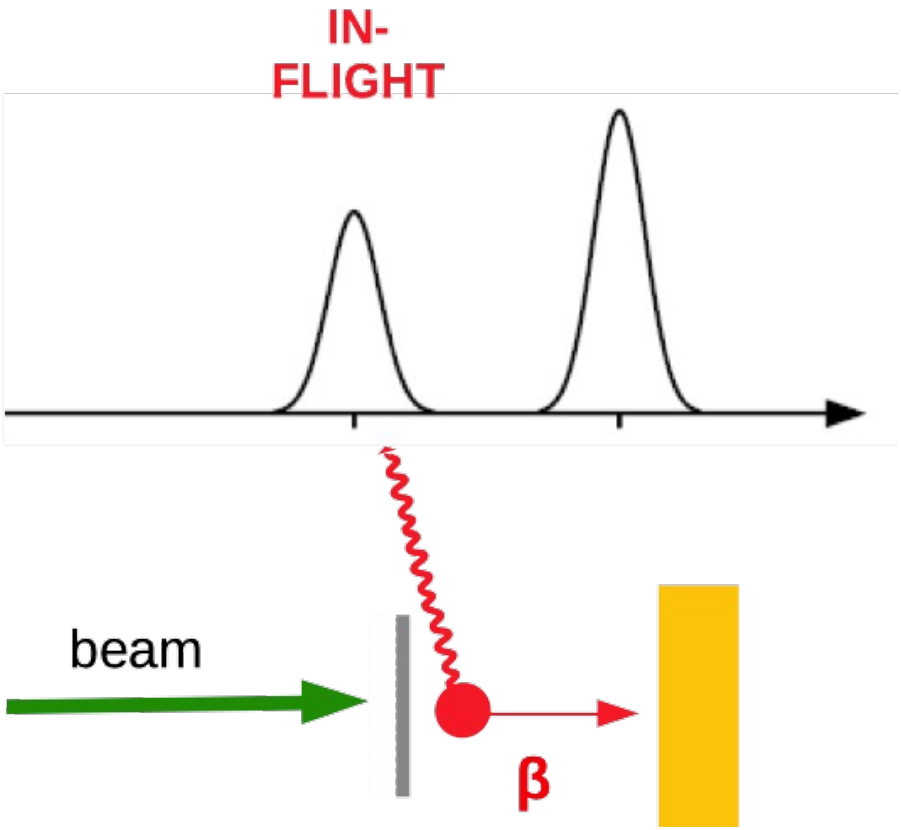


The plunger device

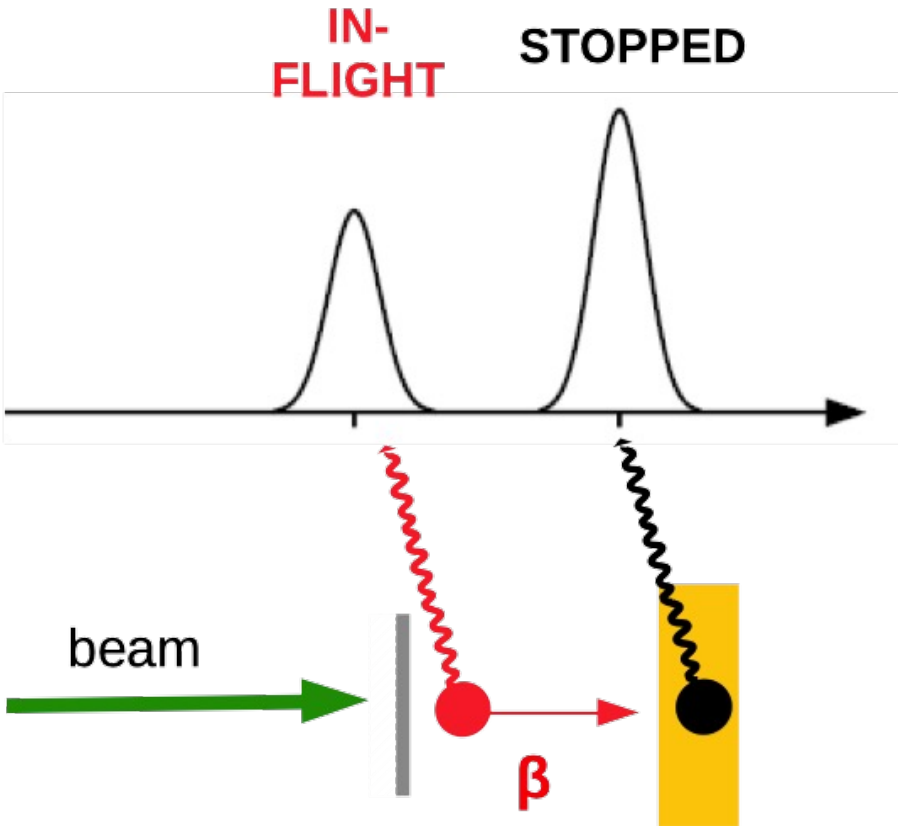
- **Two metallic foils: target and degrader;**
- **Motor with sub-micrometric precision;**
- **Feedback system;**
- **Access to lifetimes in the range of picosecond.**



RDDS method

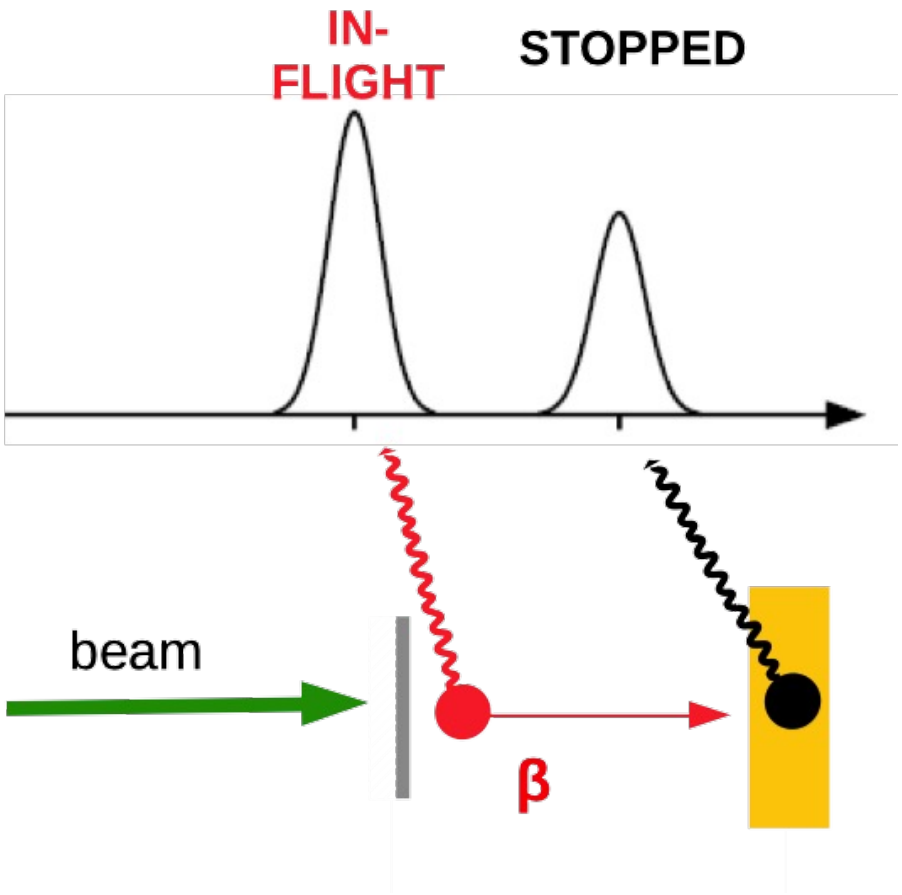


RDDS method



$$Ratio = \frac{ST}{(IF + ST)}$$

RDDS method

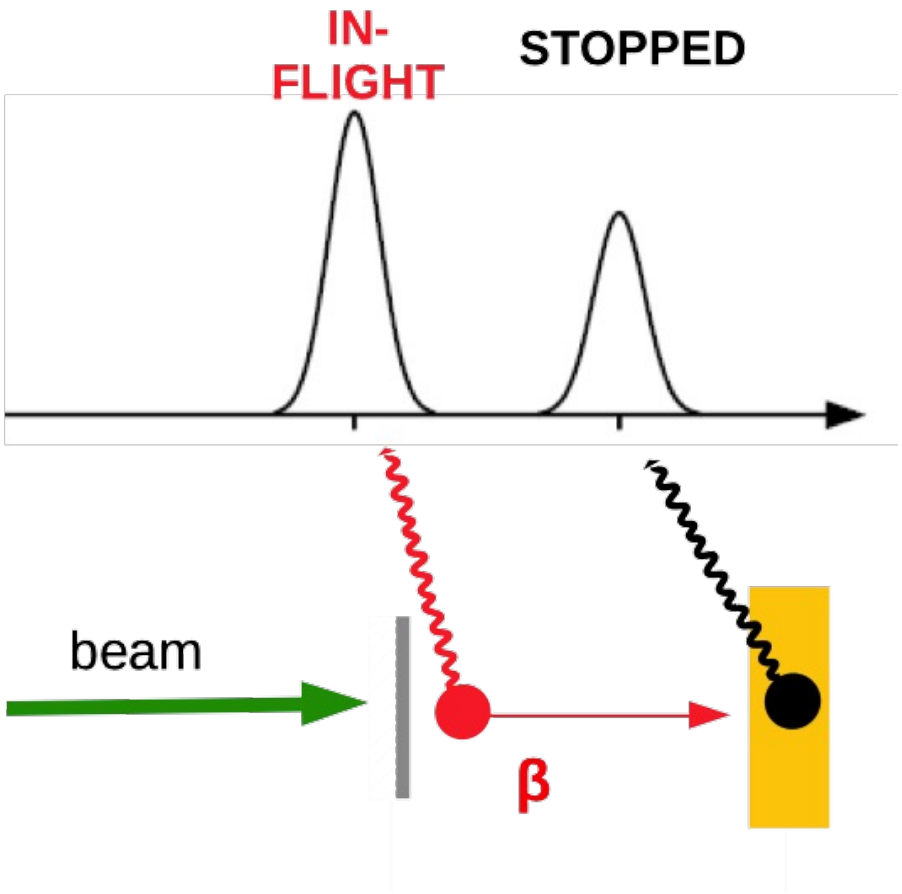


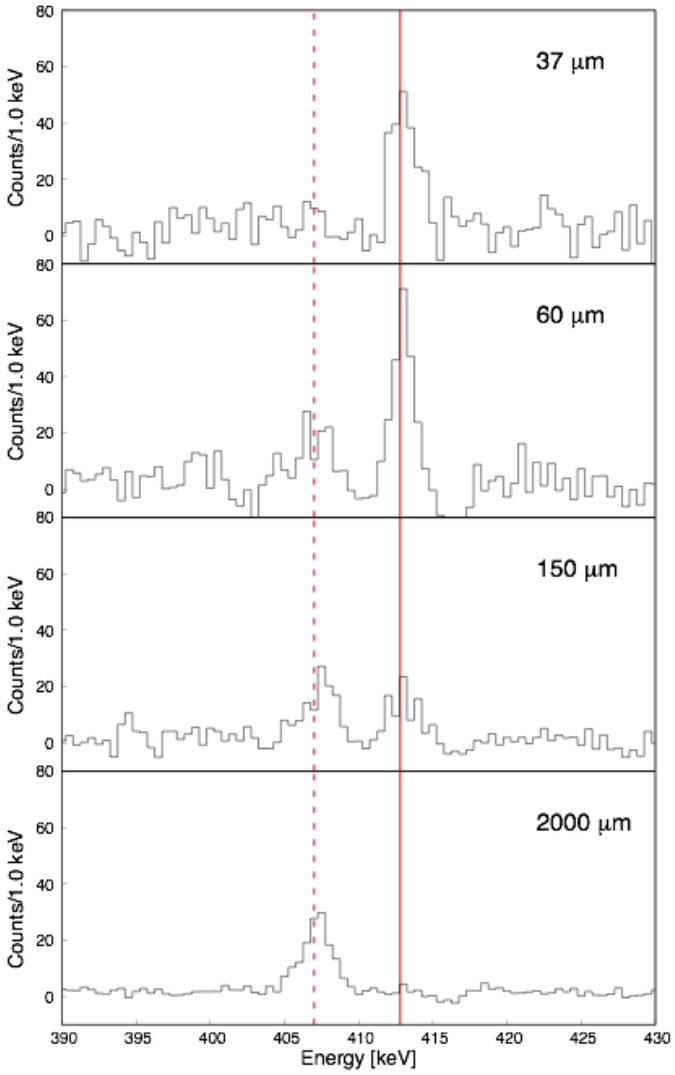
$$Ratio = \frac{ST}{(IF + ST)}$$

Depends on:

- the speed;
- the distance;
- the lifetime!

RDDS method


IN-
FLIGHT
STOPPED
beam
β


37 μm
60 μm
150 μm
2000 μm
Counts/1.0 keV
Energy [keV]

DCM and DDCM

Decay Curve Method

$$R(t) = A\, e^{-t/\tau}$$

Fitted

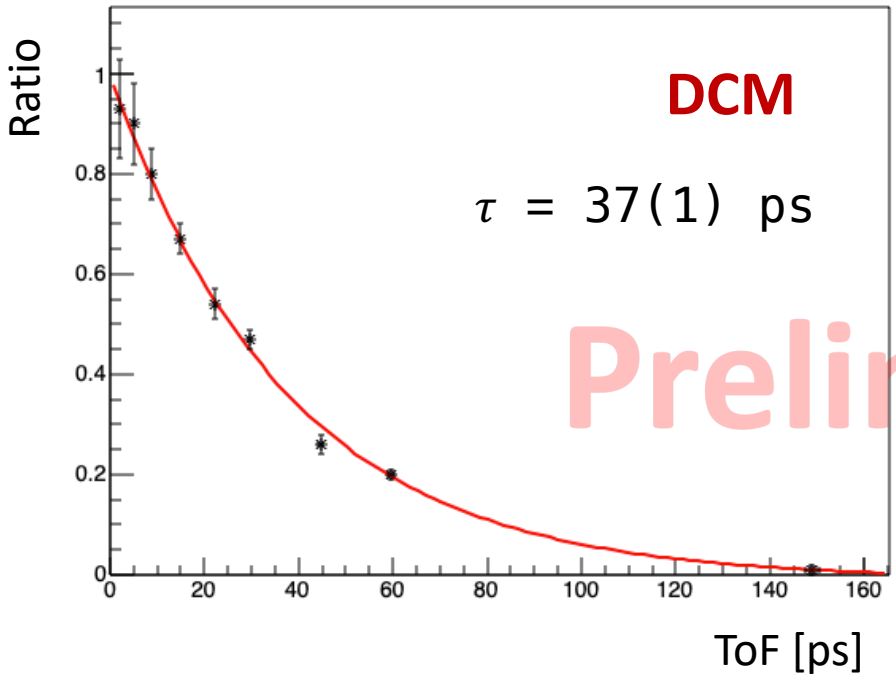
1 decay curve = 1 lifetime

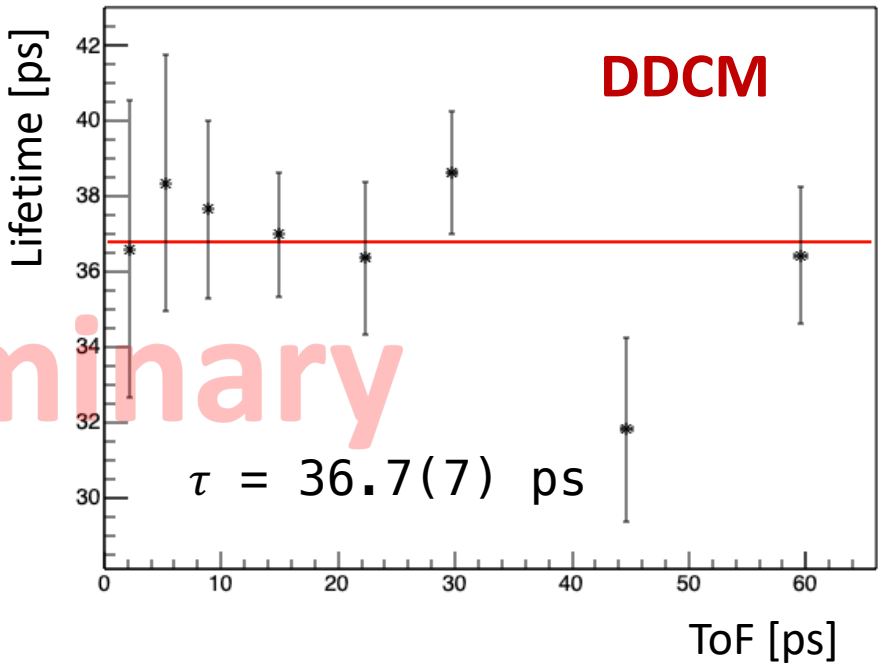
Differential Decay Curve Method

$$\tau(t_i) = \frac{R(t_i)}{v \left.\frac{dR(t)}{dt}\right|_{t=t_i}}$$

1 decay curve = 1 lifetime per distance

The 17/2$^+$ state

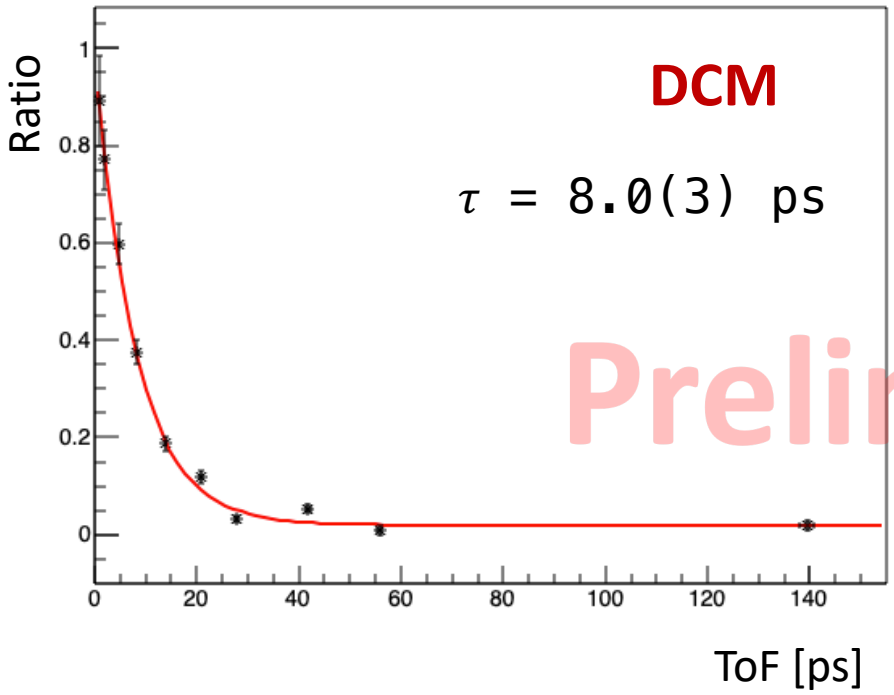


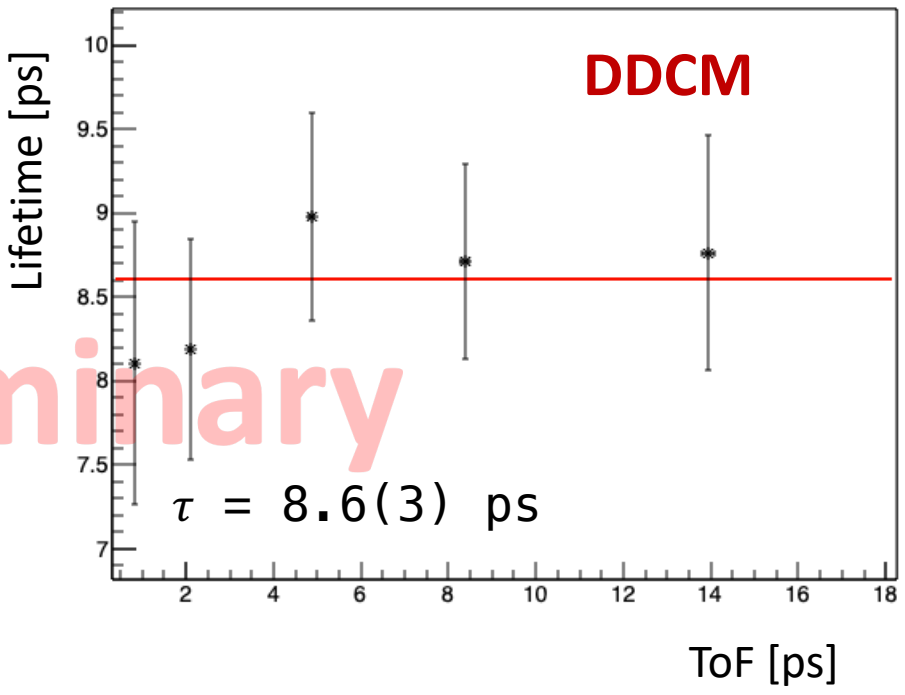


Preliminary

No agreement with previous measurement → Effect of the feeder

The $21/2^+$ state





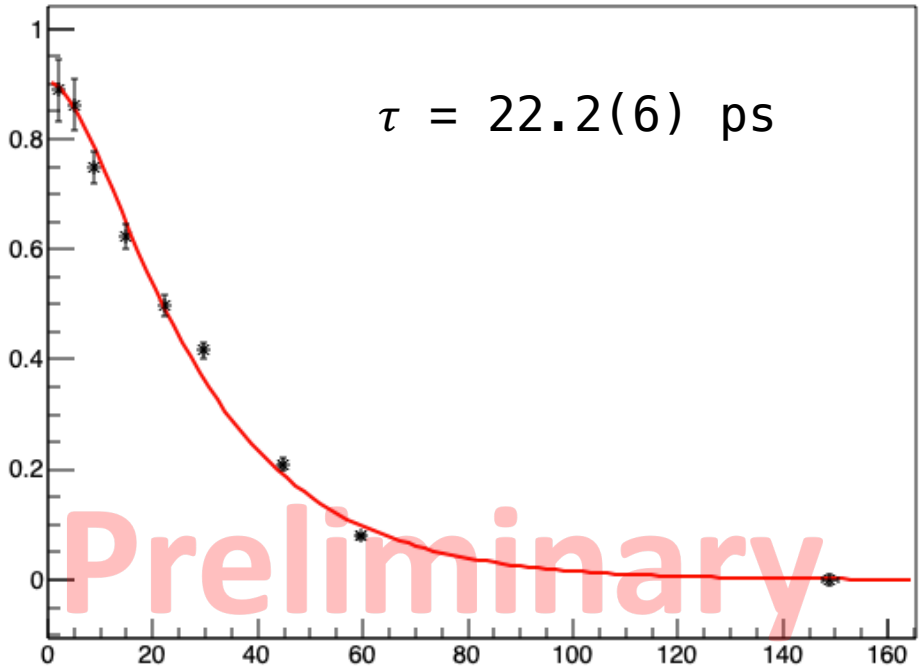
New measurement!

… now back to the $17/2^+$

Second order Bateman Eq.

$$R(t) = e^{-t/\tau 2} + \frac{\tau_1}{\tau_1 - \tau_2}\left[e^{-t/\tau 1} - e^{-t/\tau 2}\right]$$

2° order Bateman



Lifetime of $17/2^+$

Agreement with previous data:
τ = 20(4) ps
O'Donnel et al., PRC 79 (2009)

The $B_{4/2}$ ratio

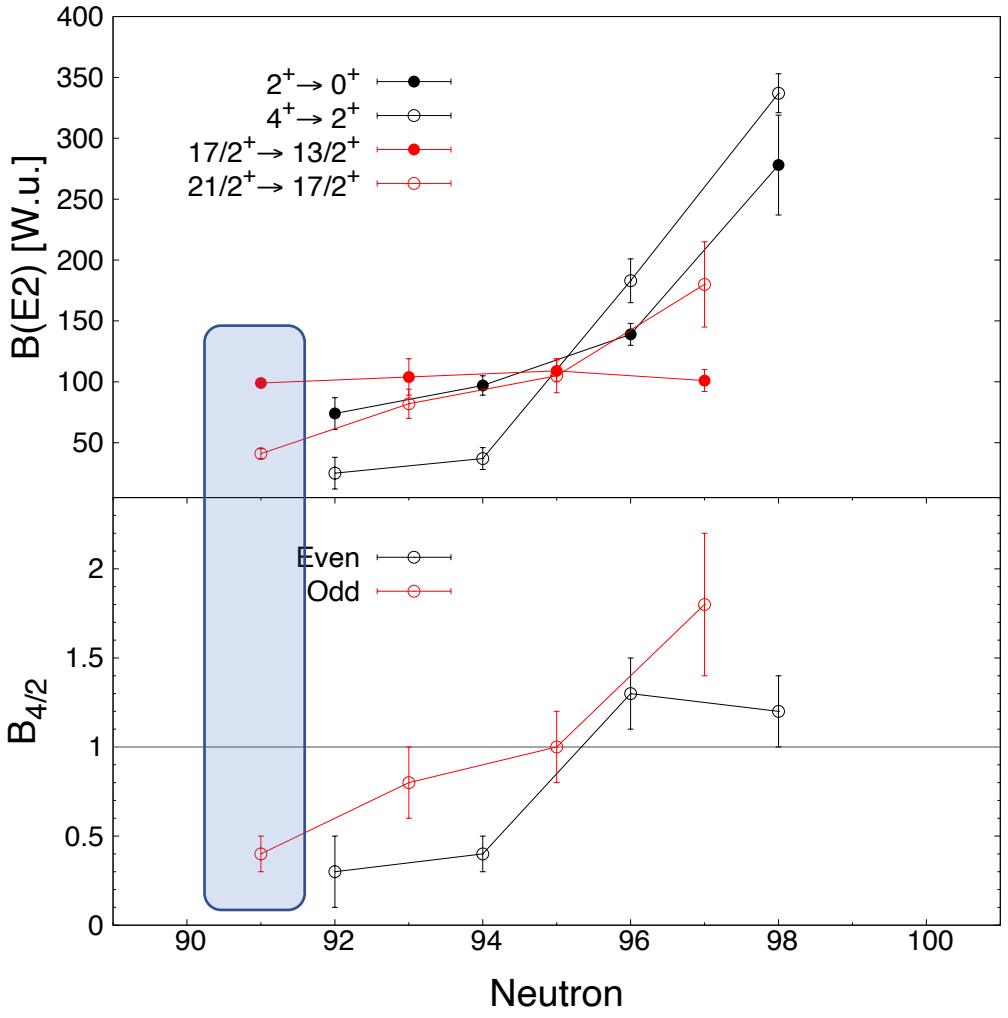
Transition	τ [ps]	B(E2) [W.u.]
$17/2^+ \rightarrow 13/2^+$	22(1)	99(5)
$21/2^+ \rightarrow 17/2^+$	8.3(5)	46(4)

$B_{4/2} \approx 0.46(6)$

The $B_{4/2}$ ratio

^{167}Os follows the trend!

… so, what's next?



Future perspective

^{166}Os? 

- 2^+ state already measured;
- 4^+ state not measurable.

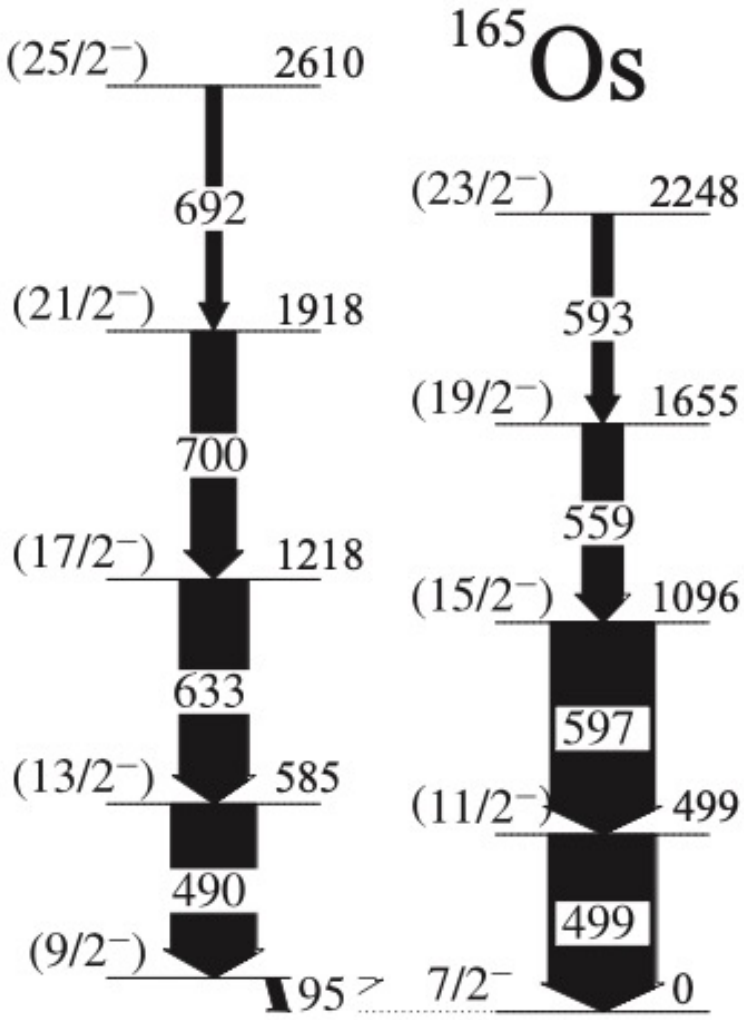
^{165}Os? 

- Spectroscopy known;
- Lifetimes unknown.

Future perspective

- Structure based on the $h_{9/2}$ band;
- Change of structure for N<90
- What $B_{4/2}$ ratio should we expect?

Experiment proposed to the JYFL PAC in Sept. 2023



Conclusions

Results:

- ^{167}Os successfully populated in the FE reaction;
- Lifetimes of $17/2^+$ and $21/2^+$ measured;

Future perspective:

- Lifetime of $25/2^+$ of ^{167}Os;
- Comparison with theory;
- Measurements of other reaction channel;
- Continuation with ^{165}Os experiment.

Thank you for your attention

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