Hg lifetime analysis

Liam P. Gaffney – University of Liverpool

Workshop on “Shape coexistence in the Pb region” – Leuven, 15th January 2012

Gammasphere + Köln plunger

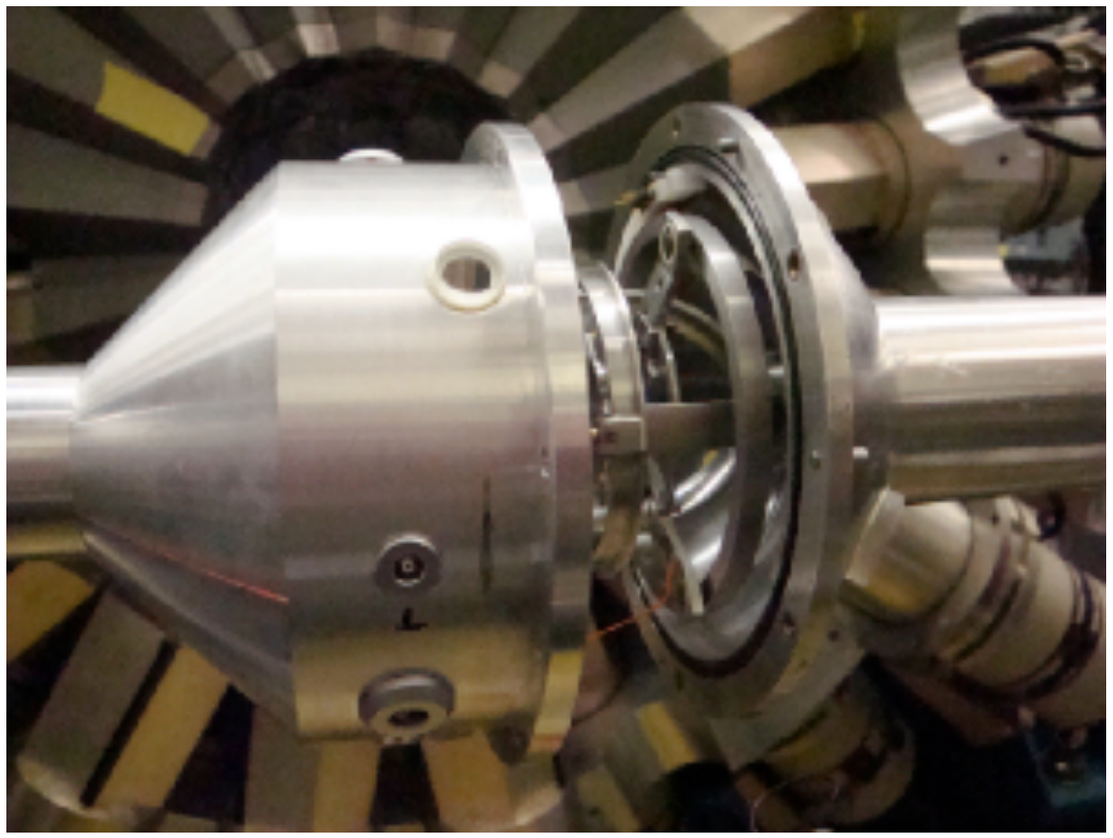
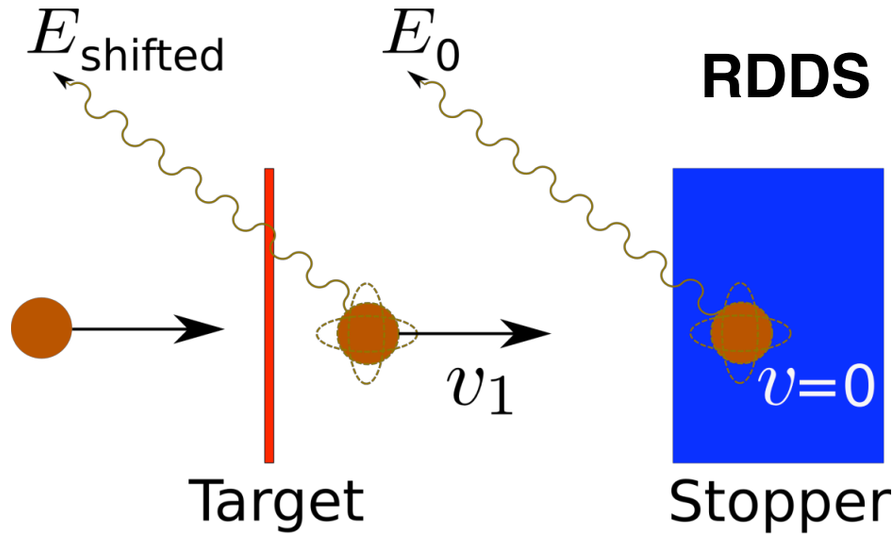
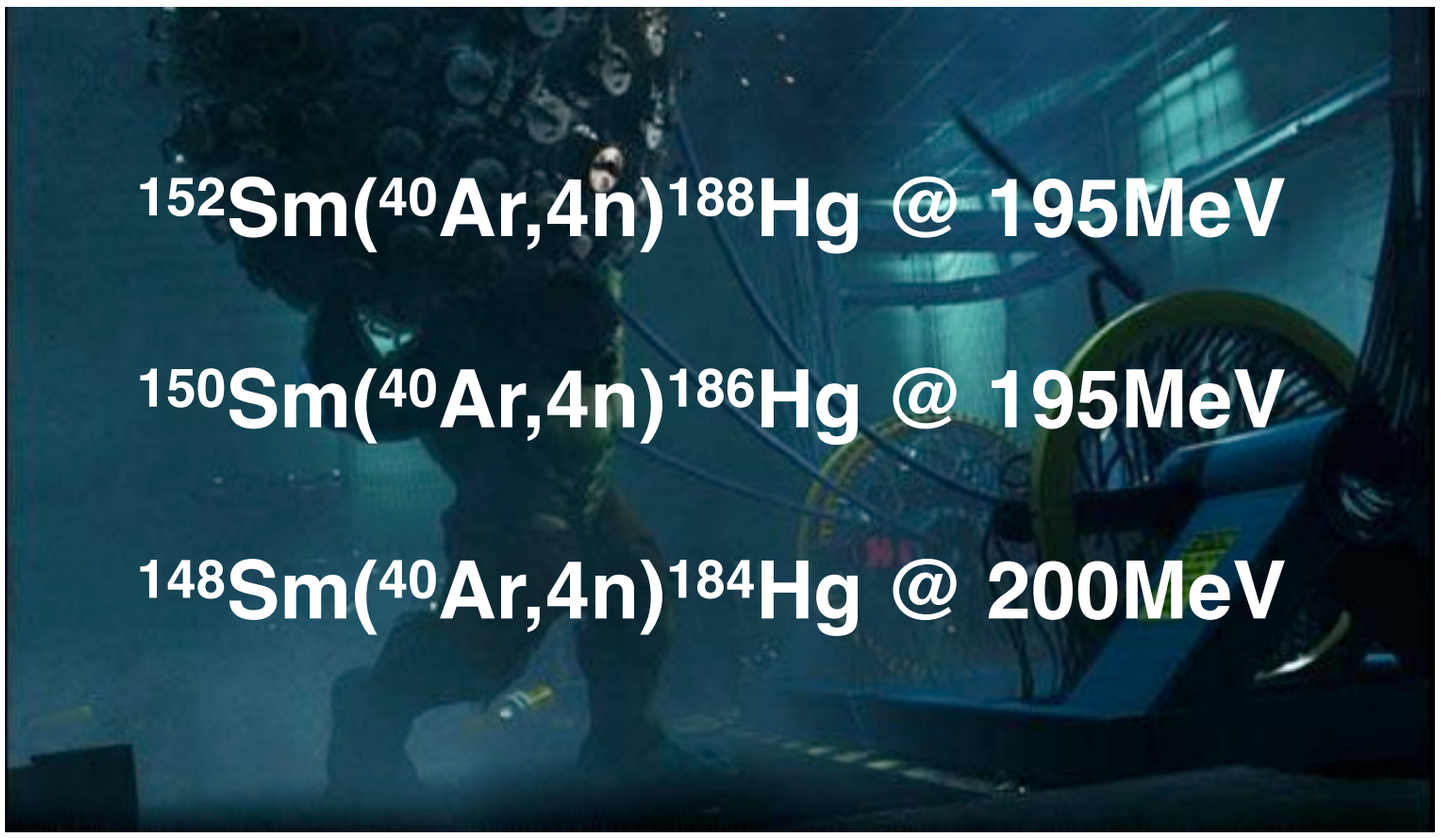


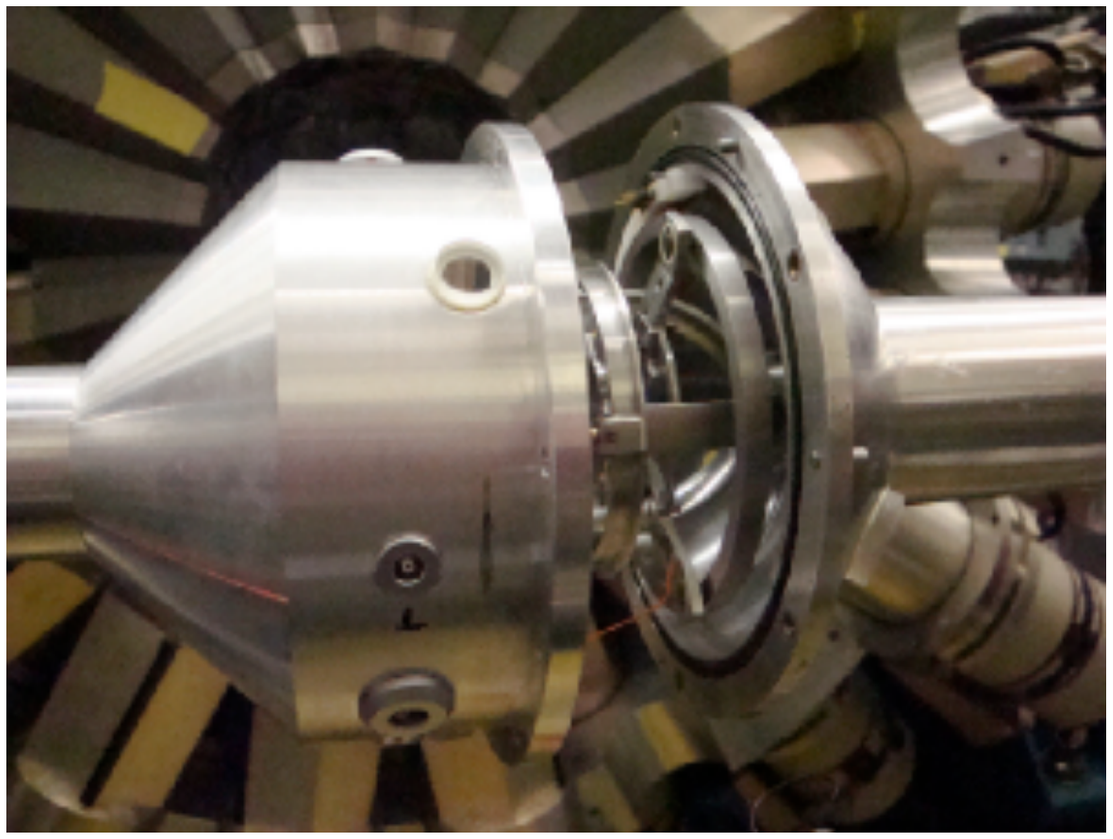
photo credit: The Hulk movie and Matthias' Hackstein



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

Gammasphere + Köln plunger





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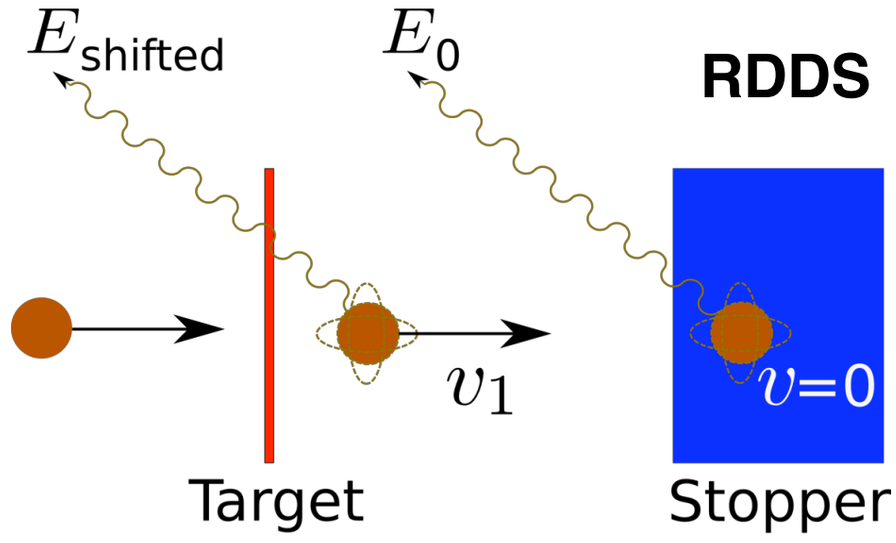

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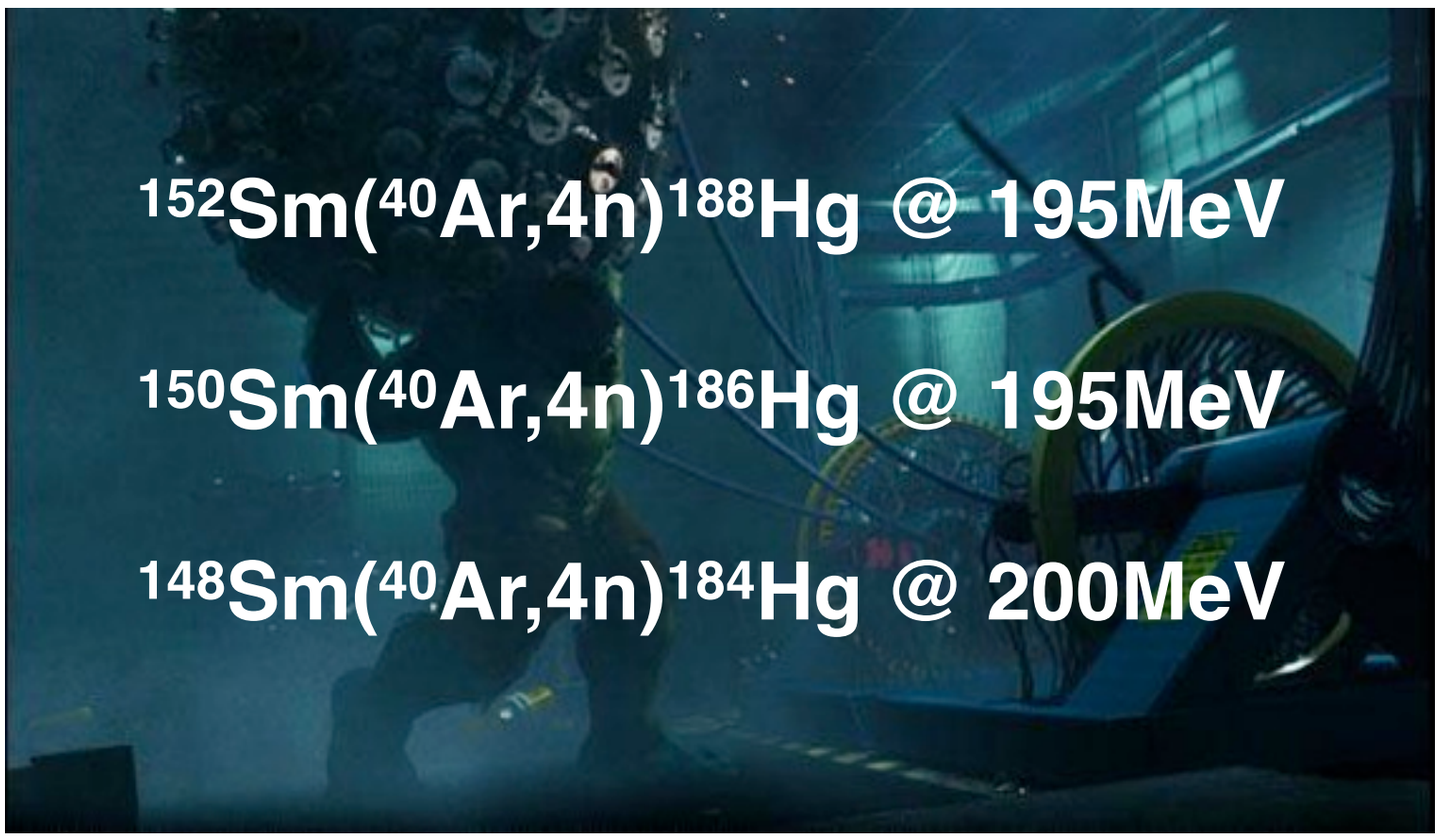

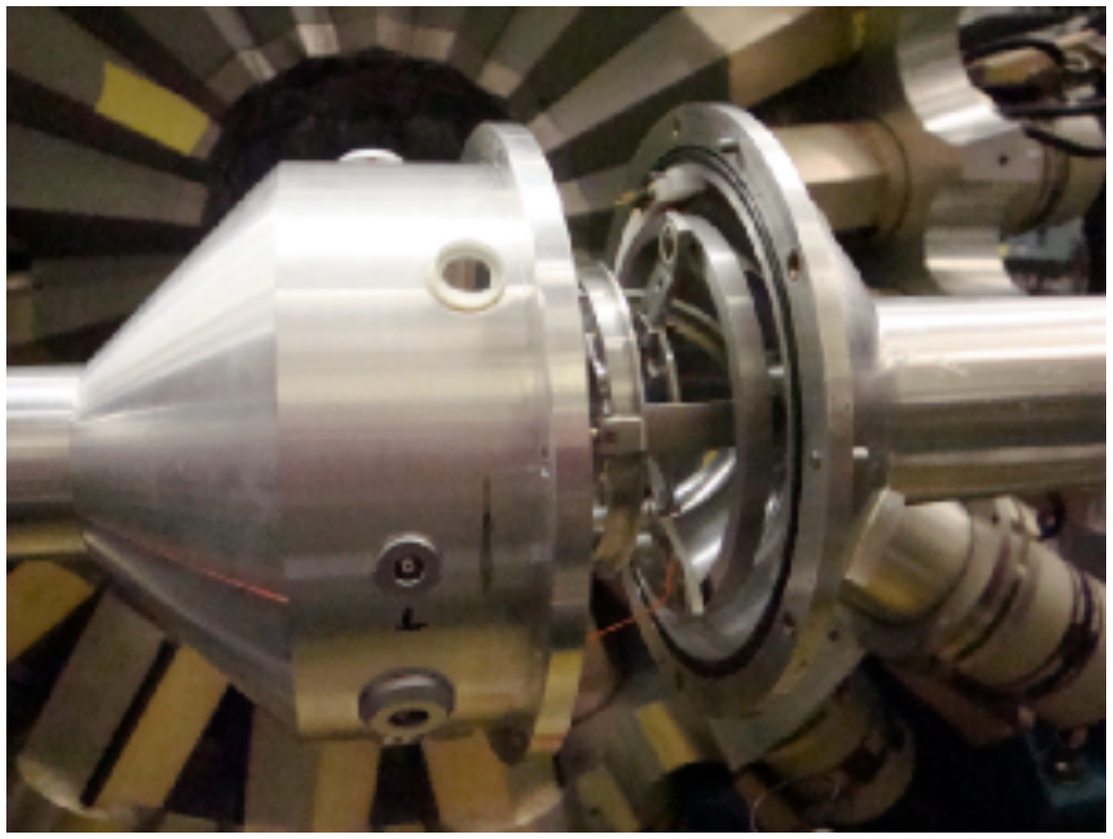

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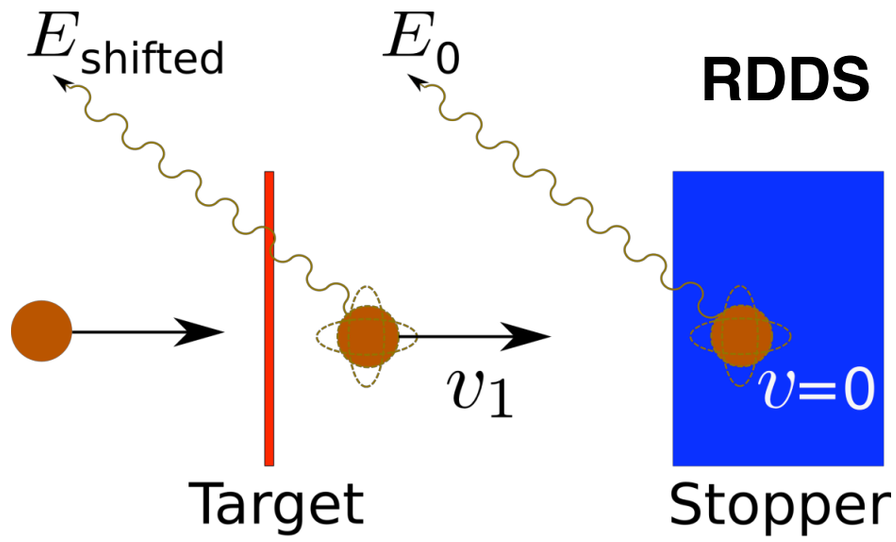
Ring	GS Angle		Ring	GS Angle	
0	17.27465	x0	9	99.29040	x5
1	31.71747	x5	10	100.81232	x5
2	37.37737	x5	11	110.17967	x10
3	50.06504	x10	12	121.71747	x5
4	58.28253	x5	13	129.93496	x10
5	69.82033	x10	14	142.62263	x5
6	79.18768	x5	15	148.28253	x5
7	80.70960	x5	16	162.72535	x5
8	90.00000	x10			

Ring	Ave Angle
A	34.54742
B	52.80420
C	69.82033
D	110.17967
E	127.19580
F	145.45258
G	162.72535



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

A matrix of matrices

AA	AB	AC	AD	AE	AF	AG
	BB	BC	BD	BE	BF	BG
		CC	CD	CE	CF	CG
			DD	DE	DF	DG
				EE	EF	EG
					FF	FG
xy						GG

- Unpacked events into γ-γ-matrices
- Each ring against all 7 rings = 28
- Gate lists for each ring and transition

A matrix of matrices

gate on y-, project to x-axis

sum 7 spectra —> Ring A

AA	AB	AC	AD	AE	AF	AG
	BB	BC	BD	BE	BF	BG
		CC	CD	CE	CF	CG
			DD	DE	DF	DG
				EE	EF	EG
					FF	FG
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A matrix of matrices

gate on y-, project to x-axis

sum 7 spectra —> Ring A

gate on y-, project to x-axis

only 4 spectra for Ring D

AA	AB	AC	AD	AE	AF	AG
	BB	BC	BD	BE	BF	BG
		CC	CD	CE	CF	CG
			DD	DE	DF	DG
				EE	EF	EG
					FF	FG
xy						GG

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- Each ring against all 7 rings = 28
- Gate lists for each ring and transition

A matrix of matrices

gate on y-, project to x-axis

sum 7 spectra —> Ring A

gate on y-, project to x-axis

only 4 spectra for Ring D

gate on x-, project to y-axis

sum 7 spectra —> Ring D

AA	AB	AC	AD	AE	AF	AG
	BB	BC	BD	BE	BF	BG
		CC	CD	CE	CF	CG
			~~DD~~	DE	DF	DG
				EE	EF	EG
					FF	FG
xy						GG

- Unpacked events into γ-γ-matrices
- Each ring against all 7 rings = 28
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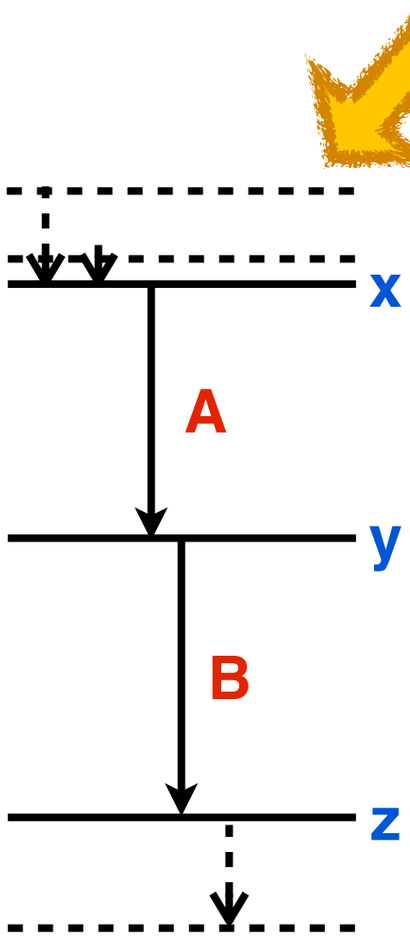
Shifted, stopped, total??

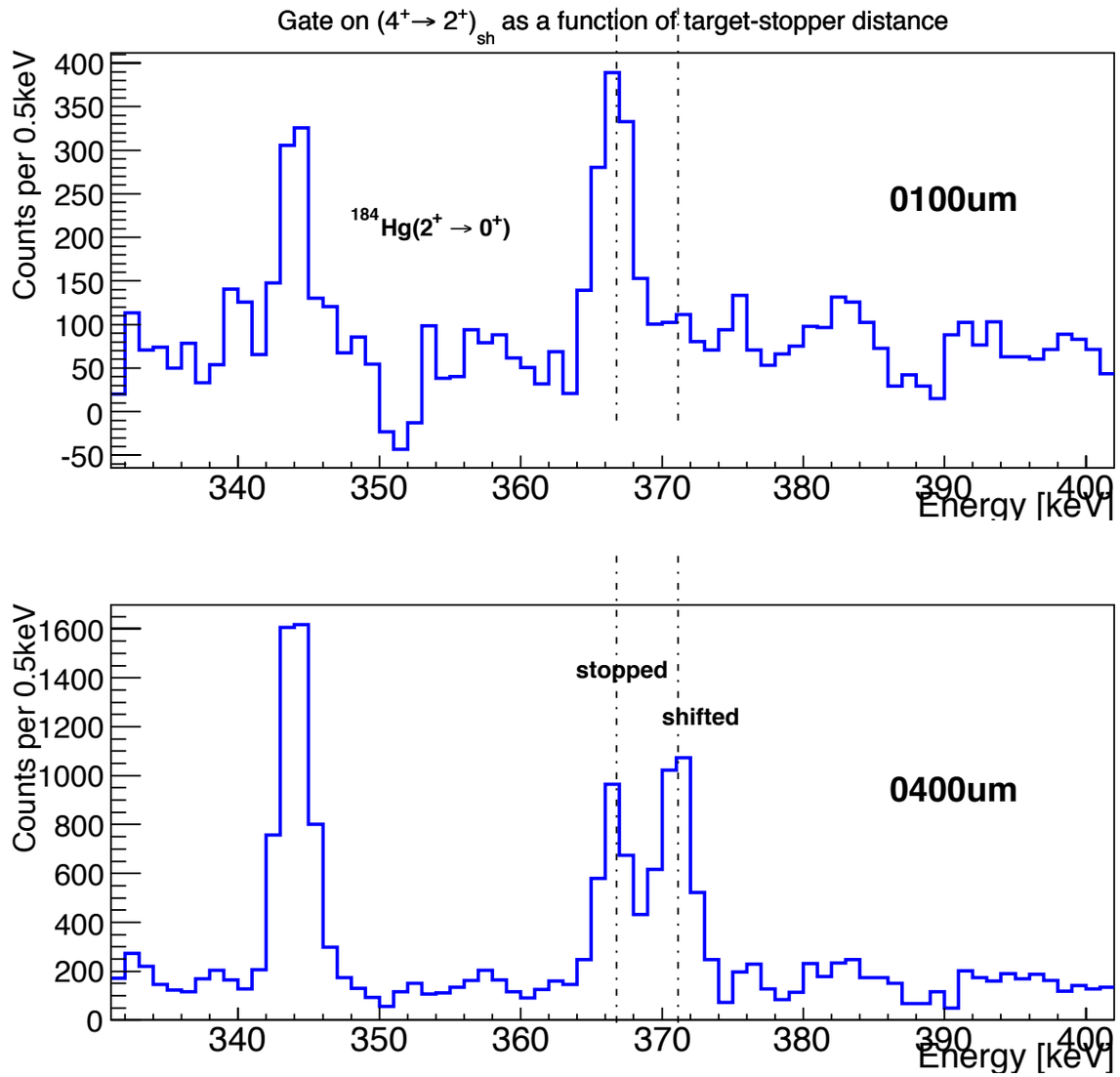


States populated following fusion evaporation

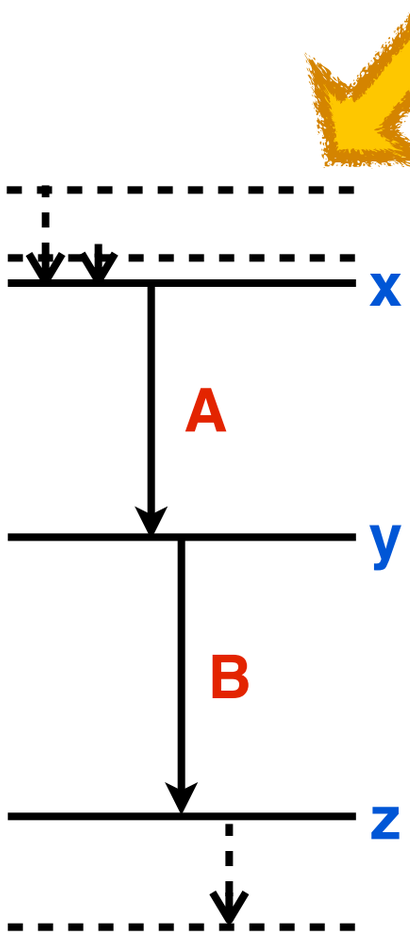
- Gate on shifted component of feeding transition, **A**

- Nucleus in flight *and* in state of interest, **y**

- Time(distance) behaviour of depopulating transition, **B**, describes lifetime of state **y** in a clean way.



Shifted, **stopped**, total??

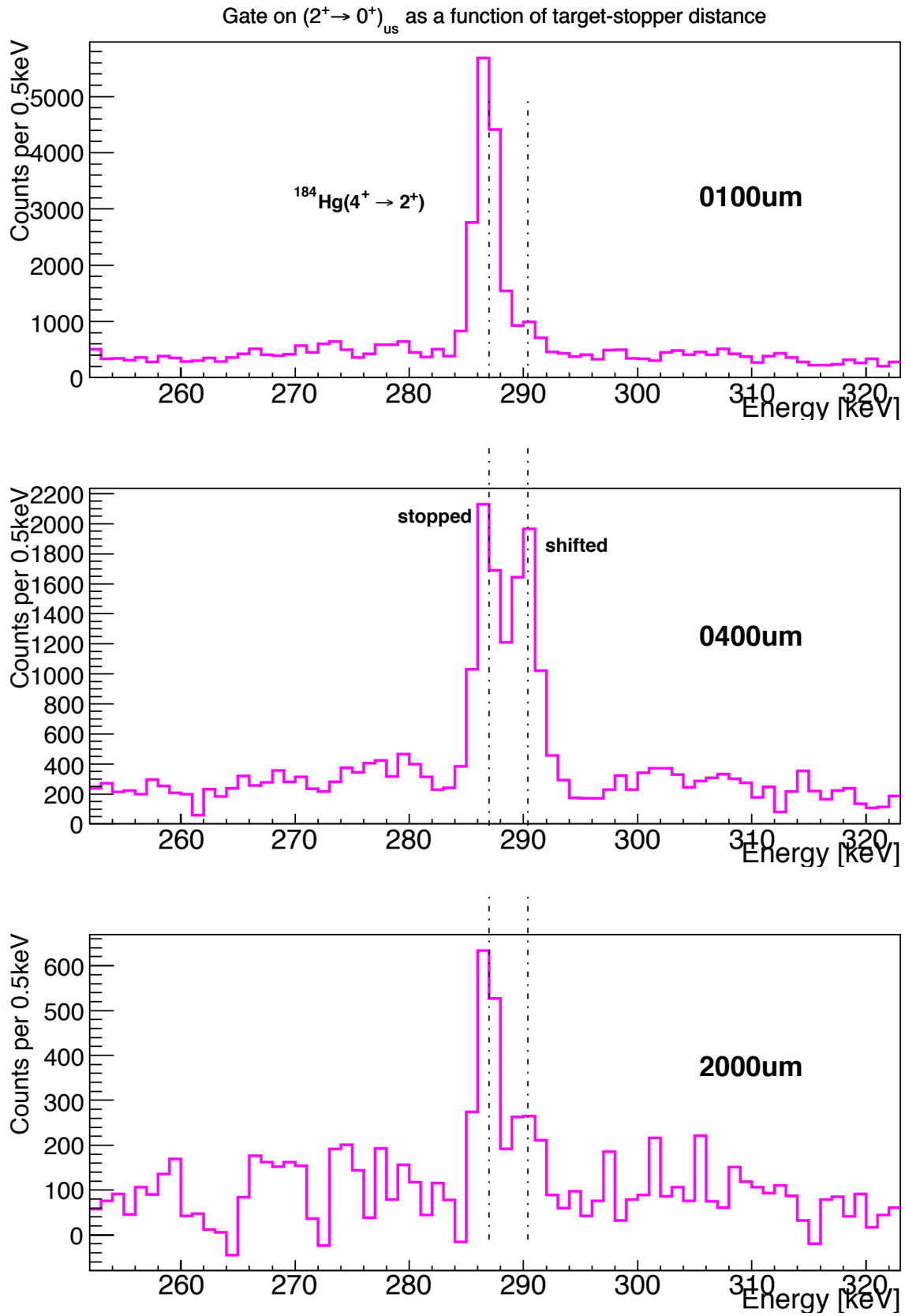


States populated following fusion evaporation

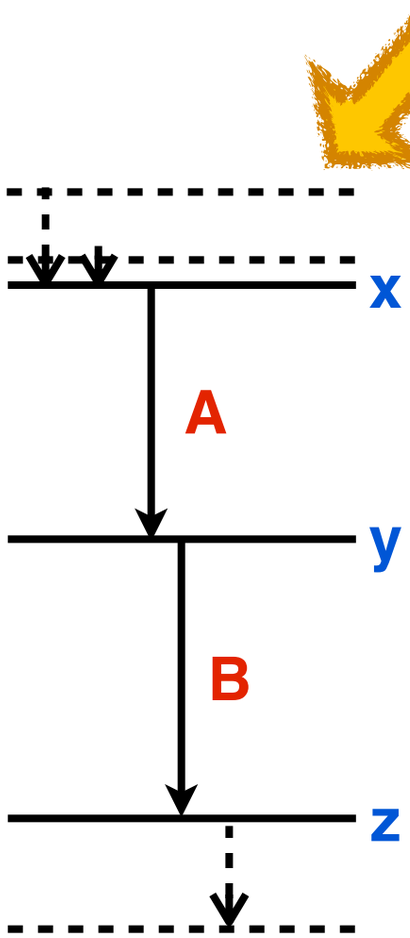
- Gate on stopped component of depopulating transition, **B**

- Nucleus stopped when **y** decays

- Time(distance) behaviour of feeding transition, **A**, describes lifetime of state **x** but susceptible to de-orientation (Matthias)



Shifted, stopped, total??

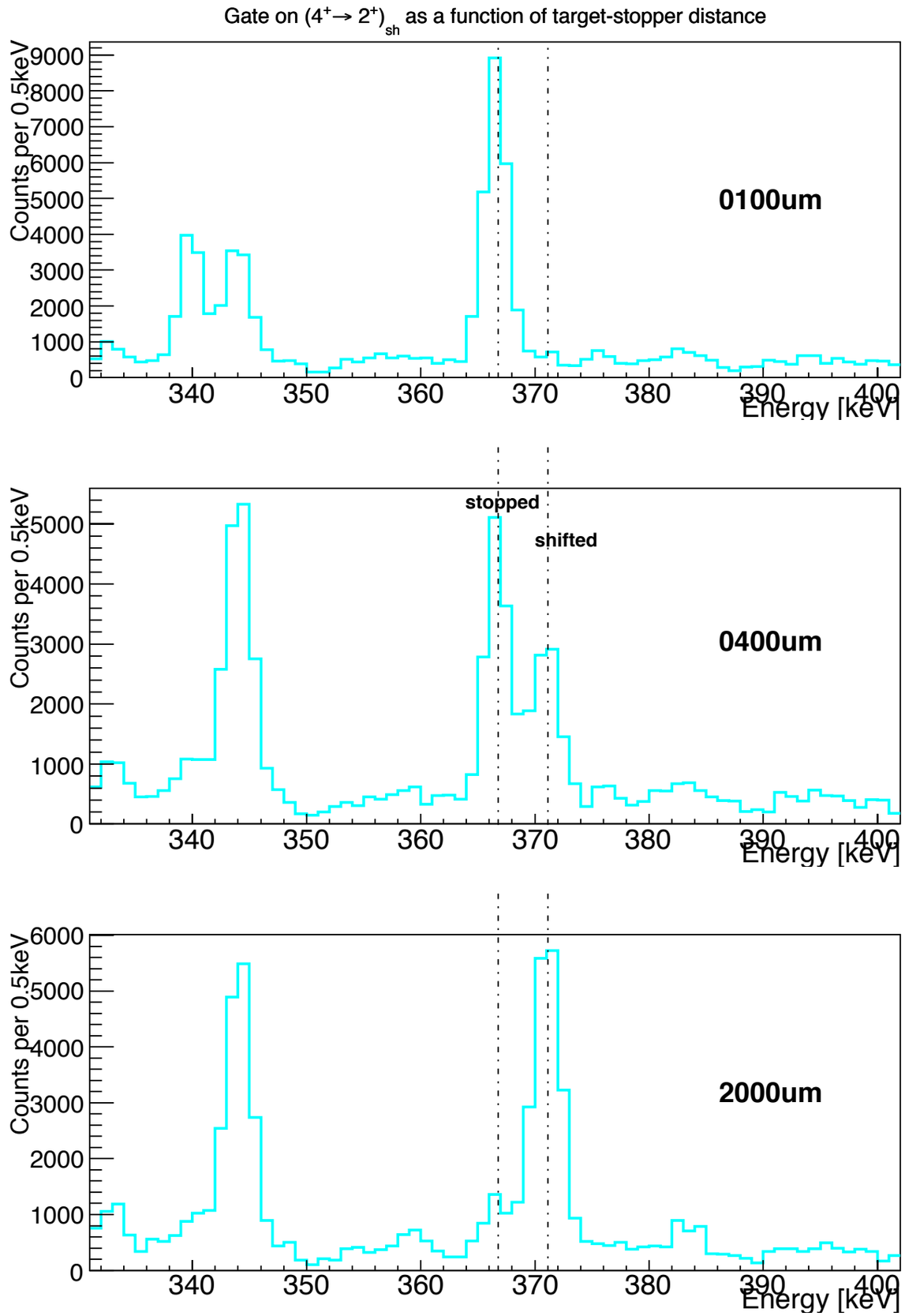


States populated following fusion evaporation

- Gate on total line-shape of depopulating transition, **B** and also, feeding, **A**

- Intensities of **A**, gated on **B** and **B** gated on **A** need to be known simultaneously

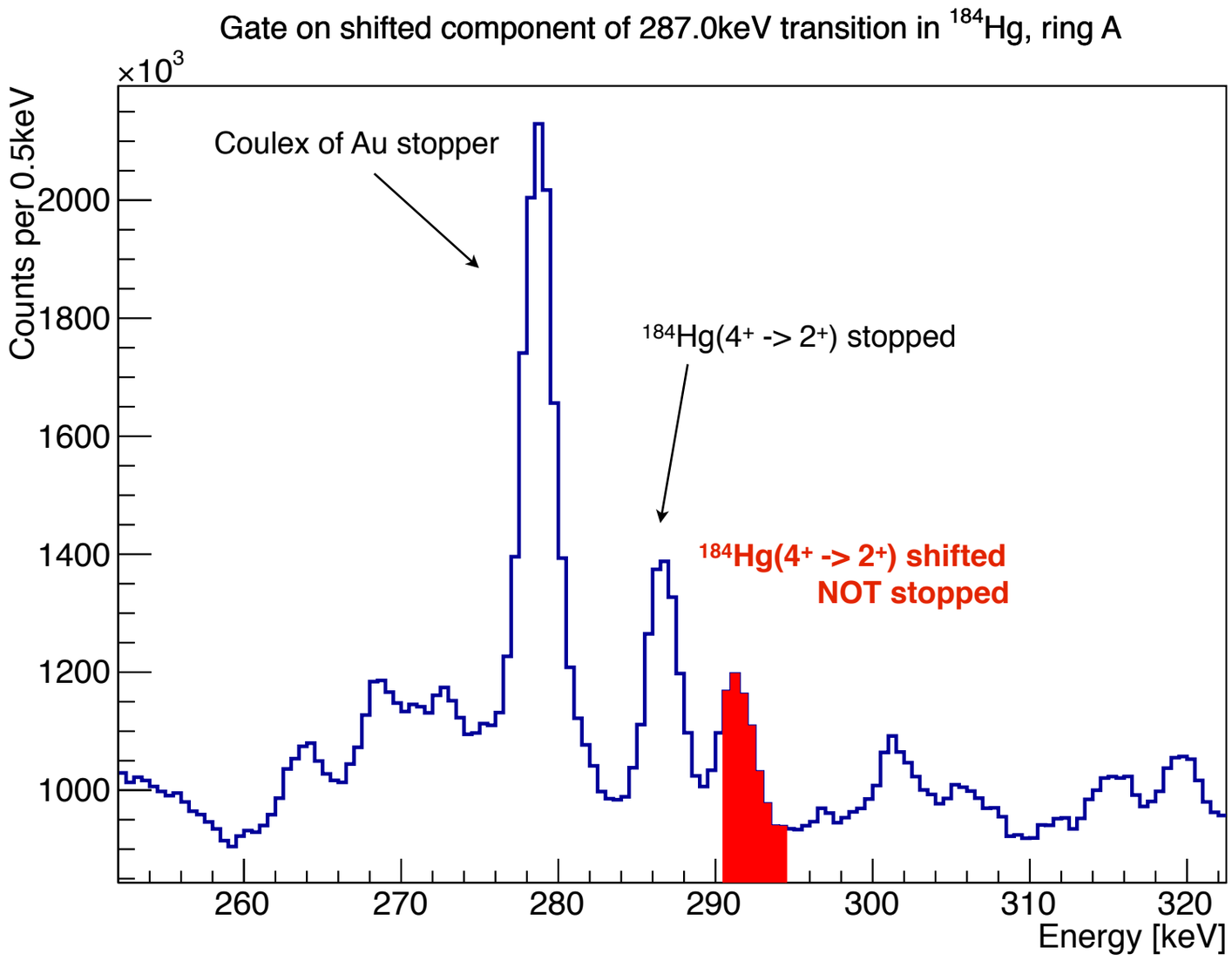
- Time(distance) behaviour of **B-A**, describes lifetime of state **y**



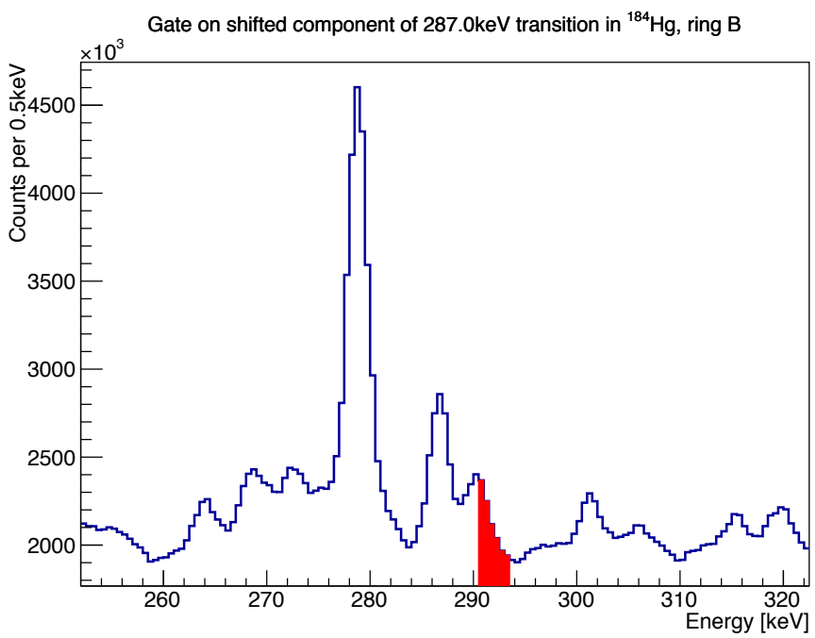
^{184}Hg - Shifted!

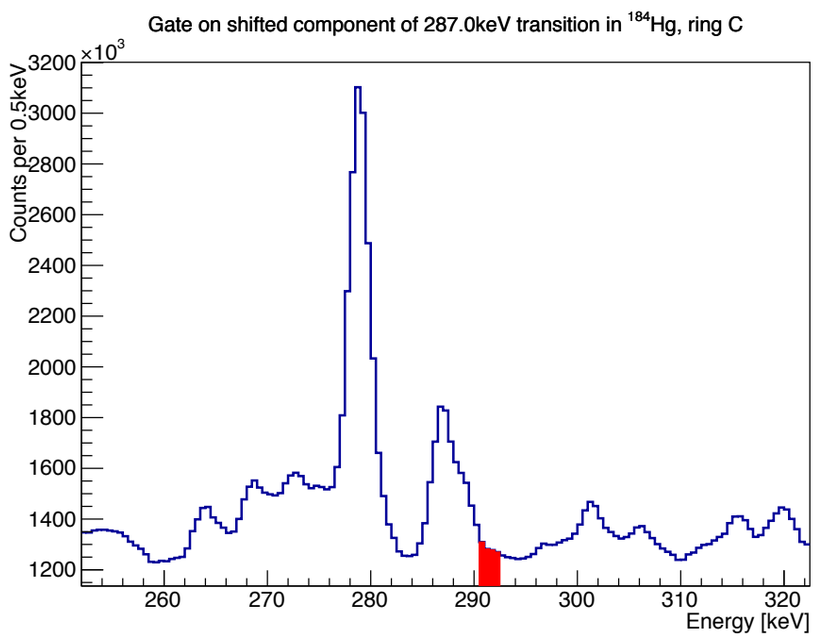
• Simplest and cleanest way of determining the lifetime with coincidence method

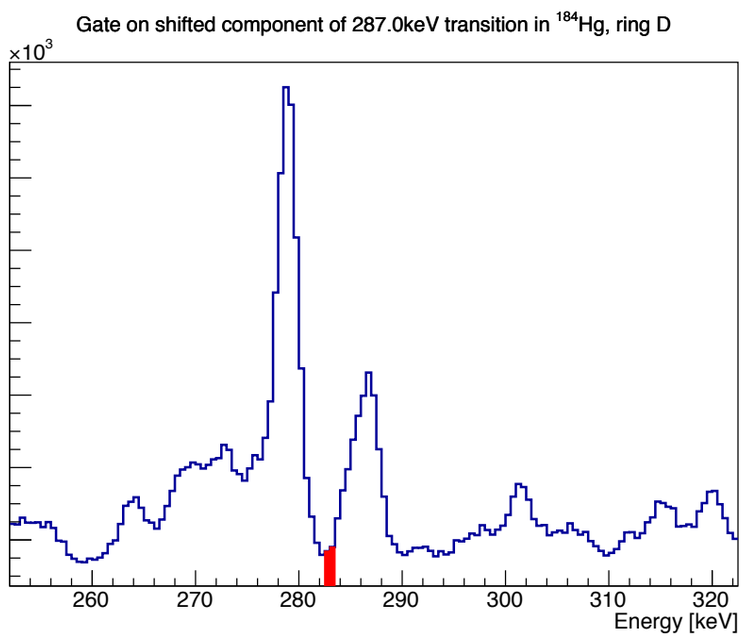
•

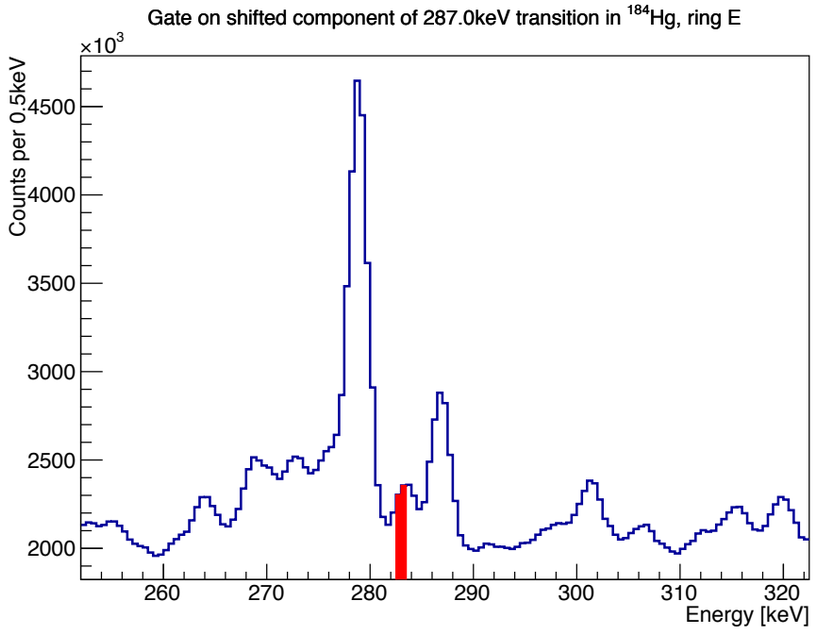


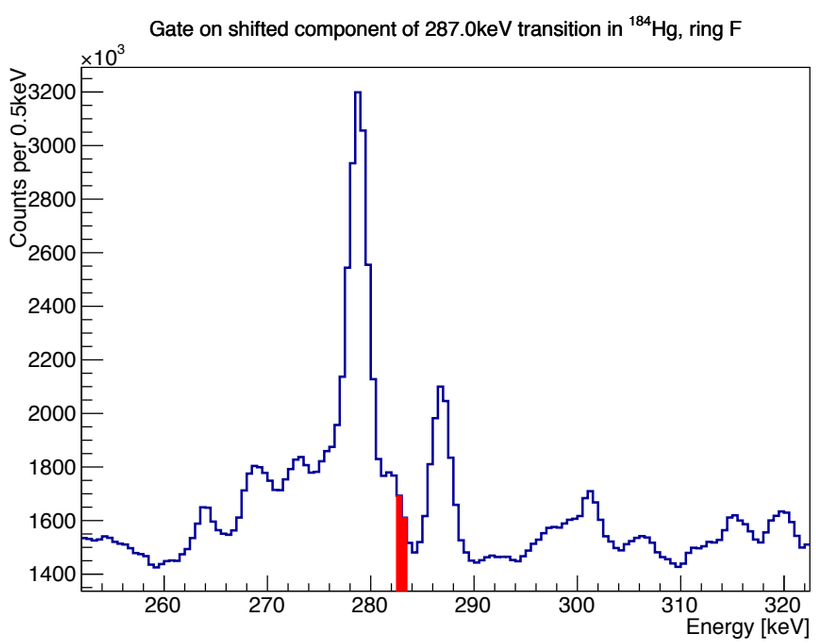
^{184}Hg - Gates

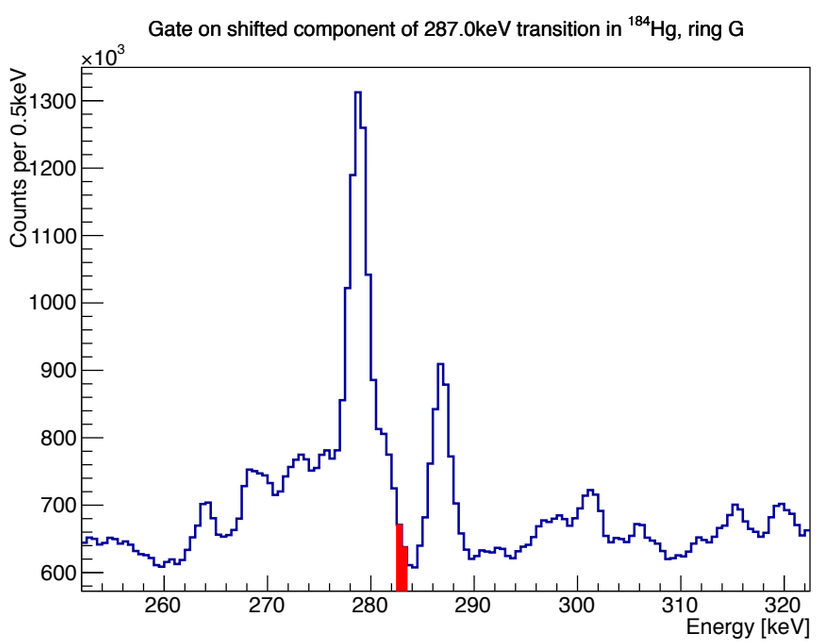

Gate on shifted component of 287.0keV transition in ^{184}Hg, ring B
Counts per 0.5keV
×10^3
Energy [keV]


Gate on shifted component of 287.0keV transition in ^{184}Hg, ring C
Counts per 0.5keV
×10^3
Energy [keV]


Gate on shifted component of 287.0keV transition in ^{184}Hg, ring D
×10^3
Energy [keV]

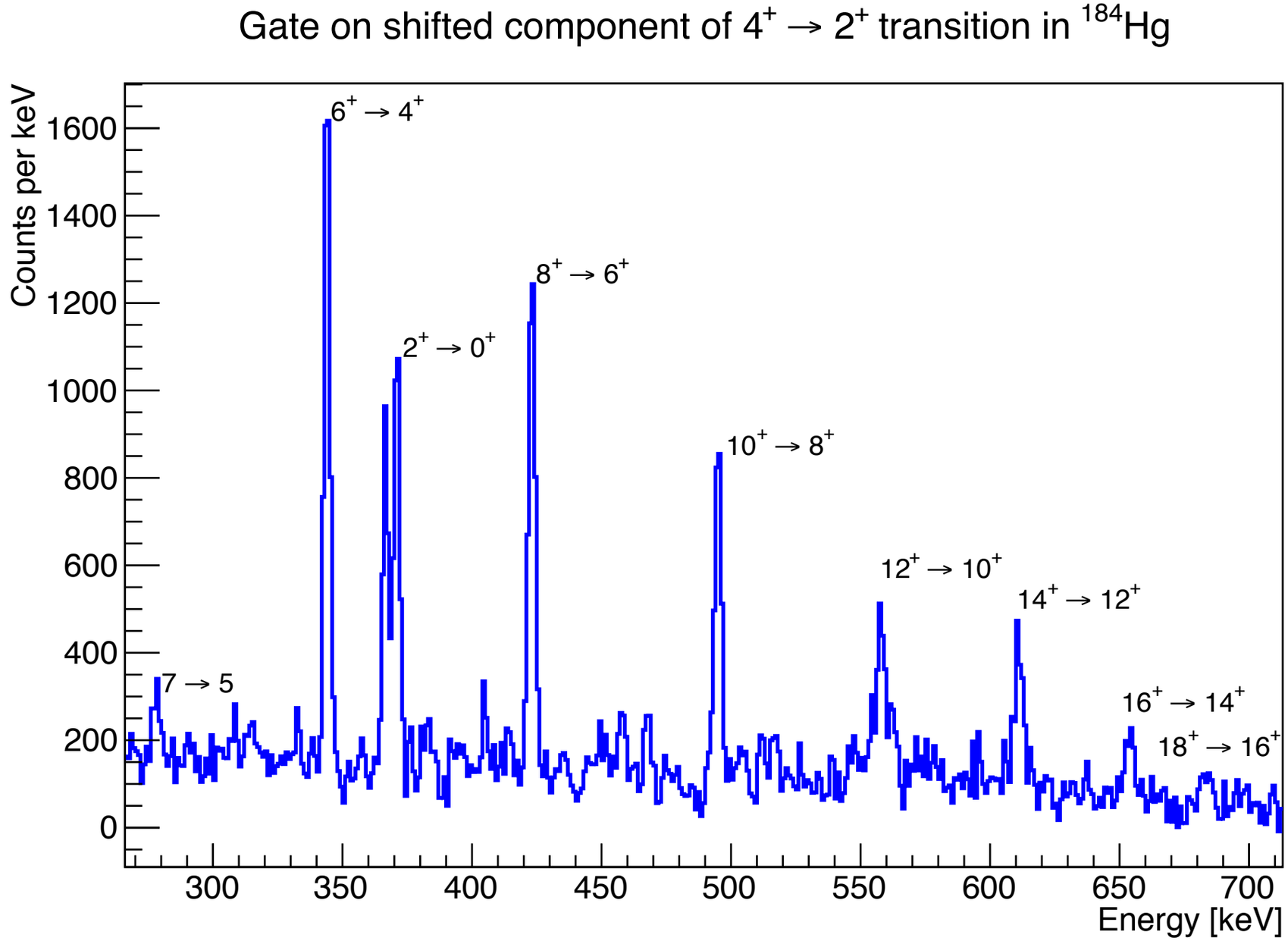

Gate on shifted component of 287.0keV transition in ^{184}Hg, ring E
Counts per 0.5keV
×10^3
Energy [keV]


Gate on shifted component of 287.0keV transition in ^{184}Hg, ring F
Counts per 0.5keV
×10^3
Energy [keV]


Gate on shifted component of 287.0keV transition in ^{184}Hg, ring G
Counts per 0.5keV
×10^3
Energy [keV]

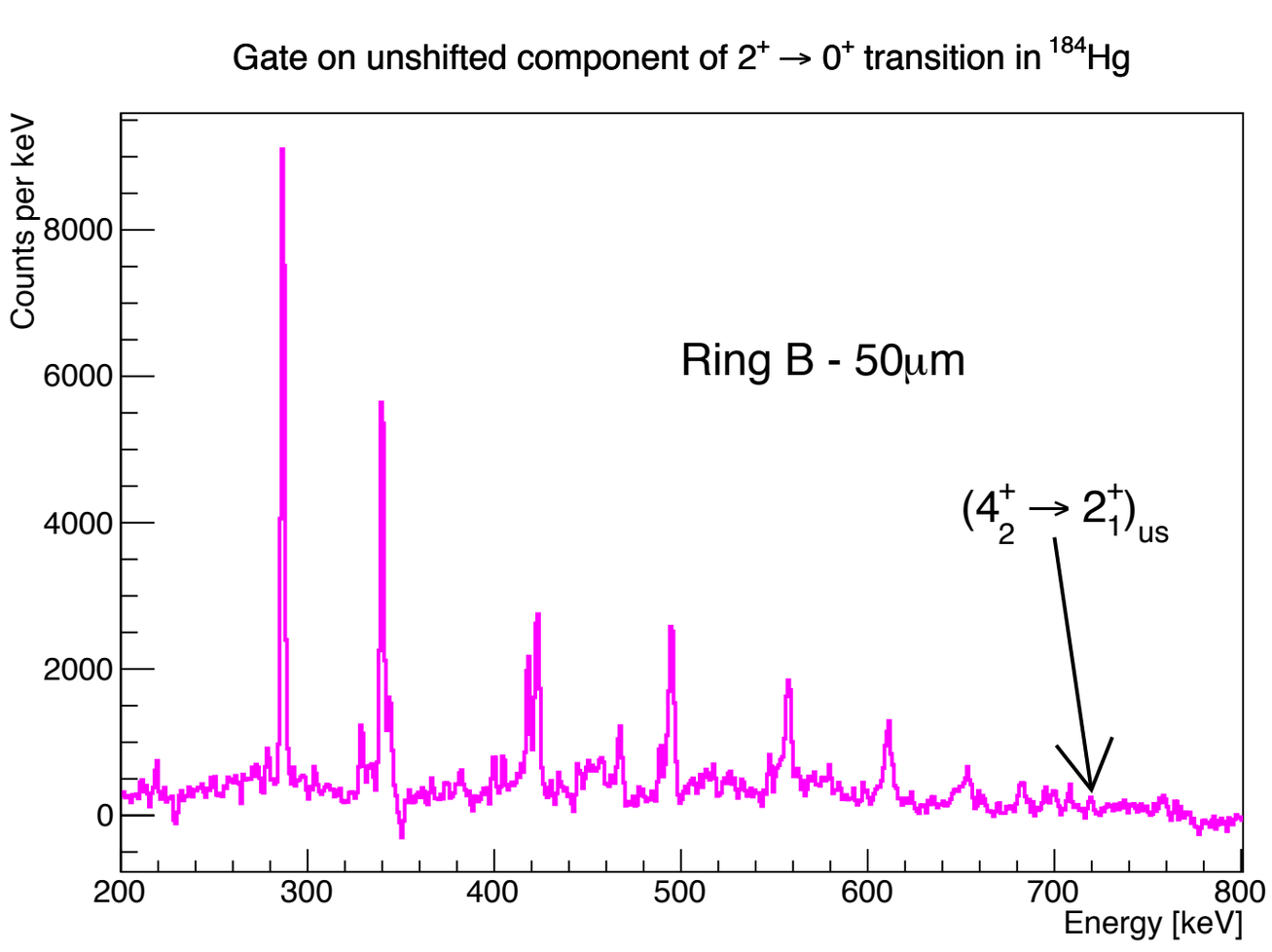
^{184}Hg - Shifted!

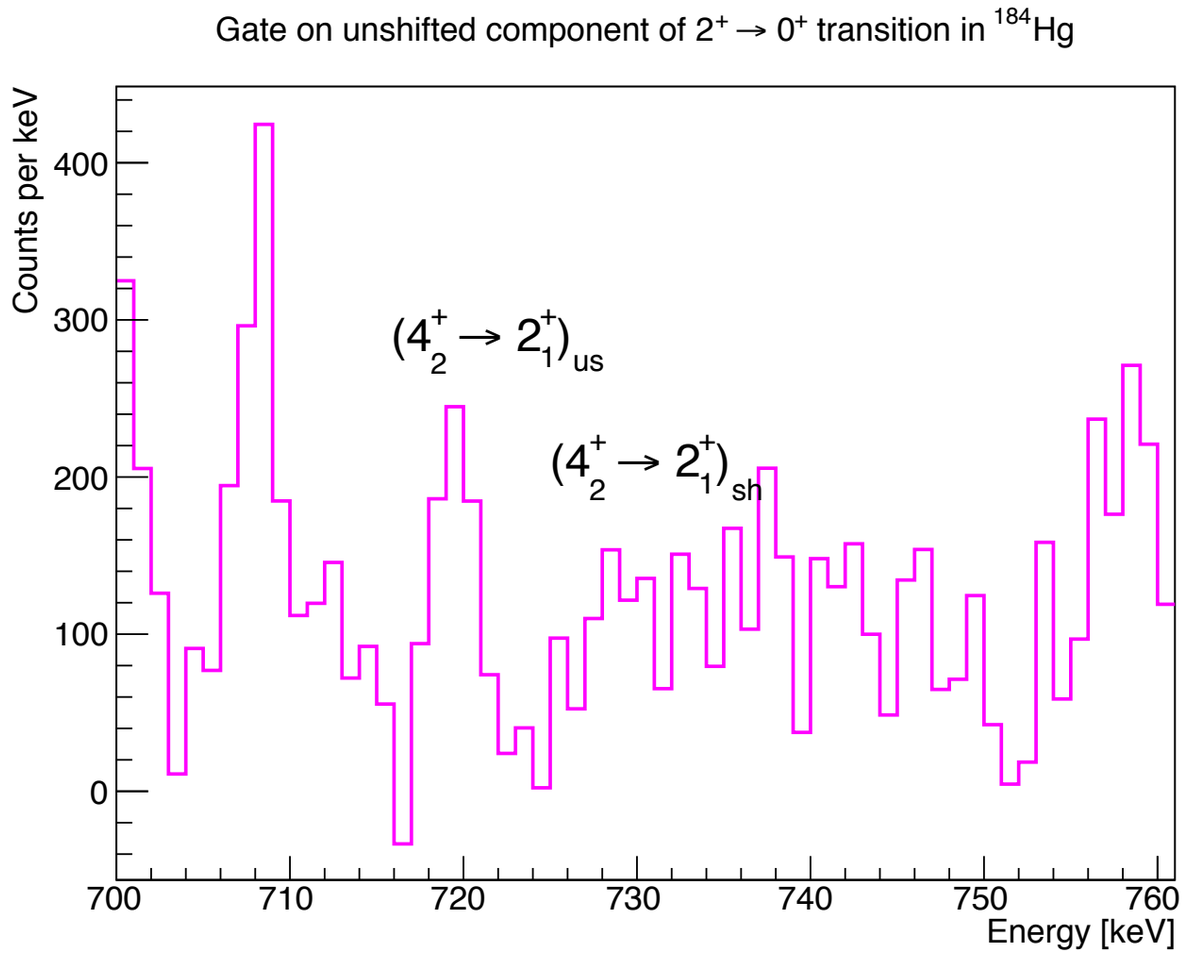
- Simplest and cleanest way of determining the lifetime with coincidence method
- Good statistics, confident gating
- Possible up to 8^+
- $12^+ \rightarrow 10^+$ not clean



^{184}Hg - Unshifted?

- Gate from below on $(2^+ \rightarrow 0^+)_{us}$ could give access to non-yrast 4^+ lifetime
- Careful gating as before
- Not enough statistics to fit shifted peak





^{184}Hg - Lifetimes

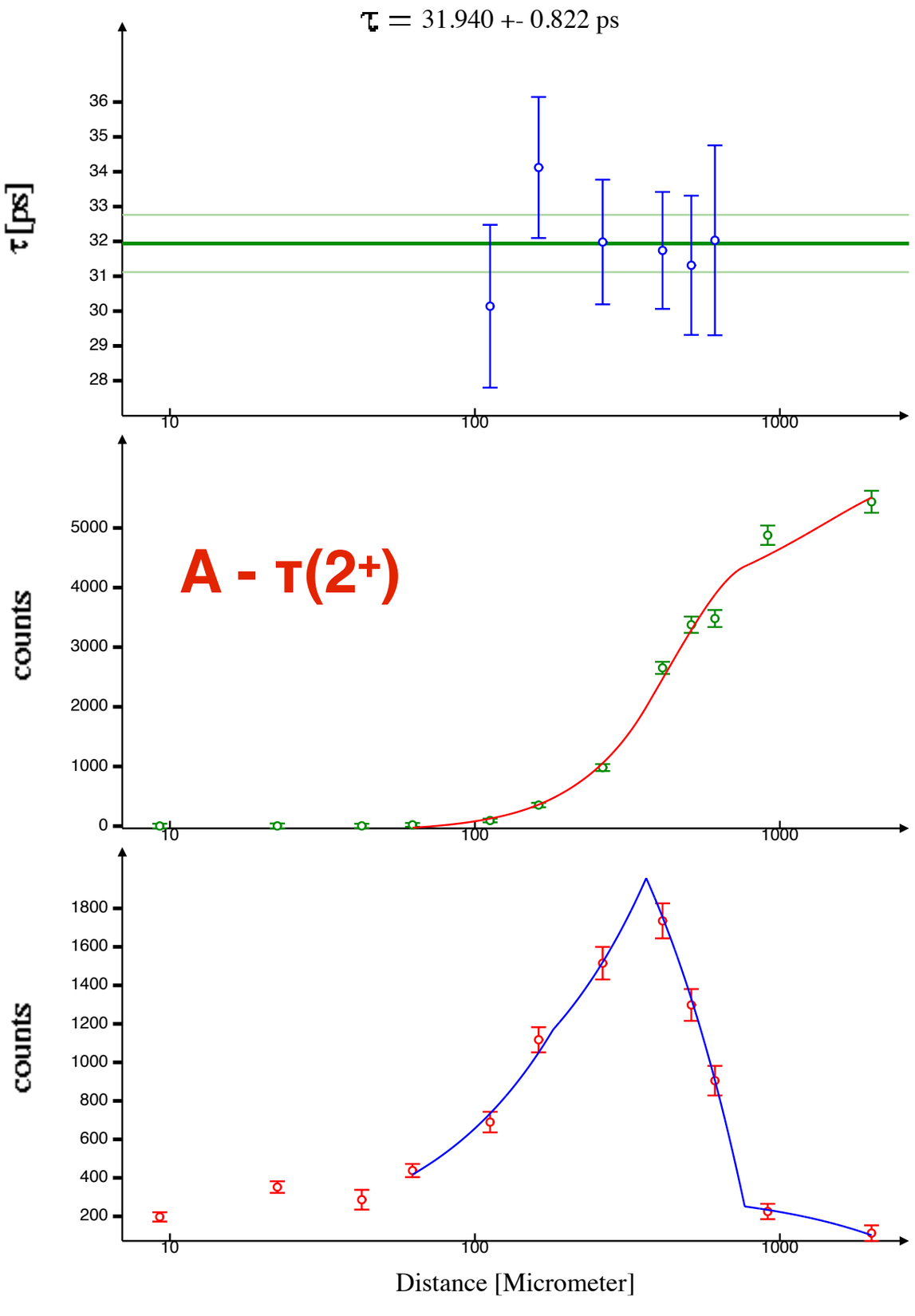
- Napatau program used to fit both shifted and unshifted intensities simultaneously.

- Polynomial fit makes for easier differential

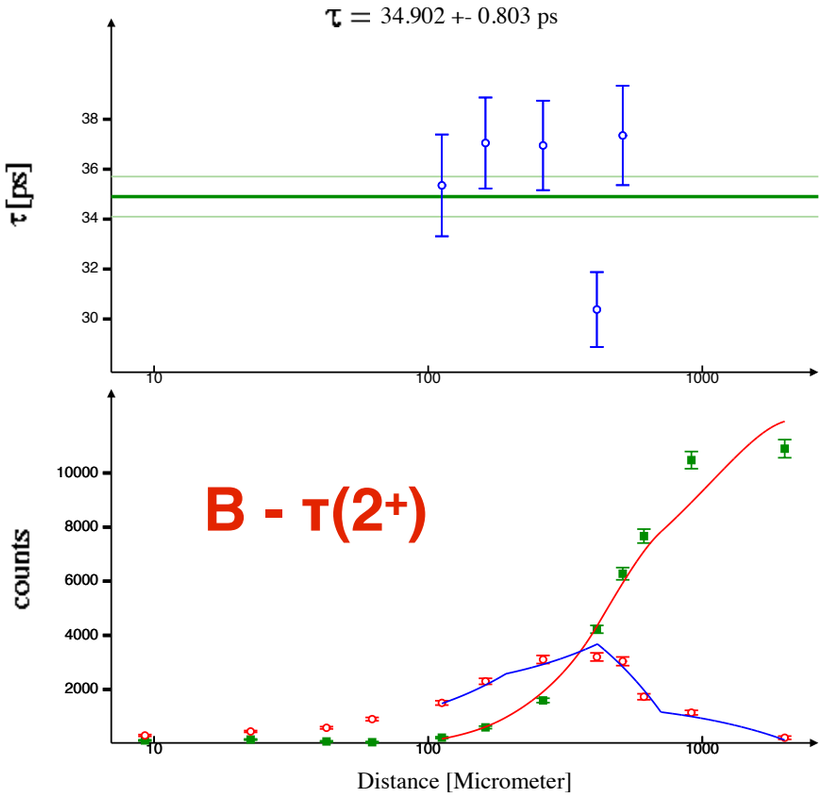
- Shifted component corrected for difference in relative efficiency (max. ~1%)

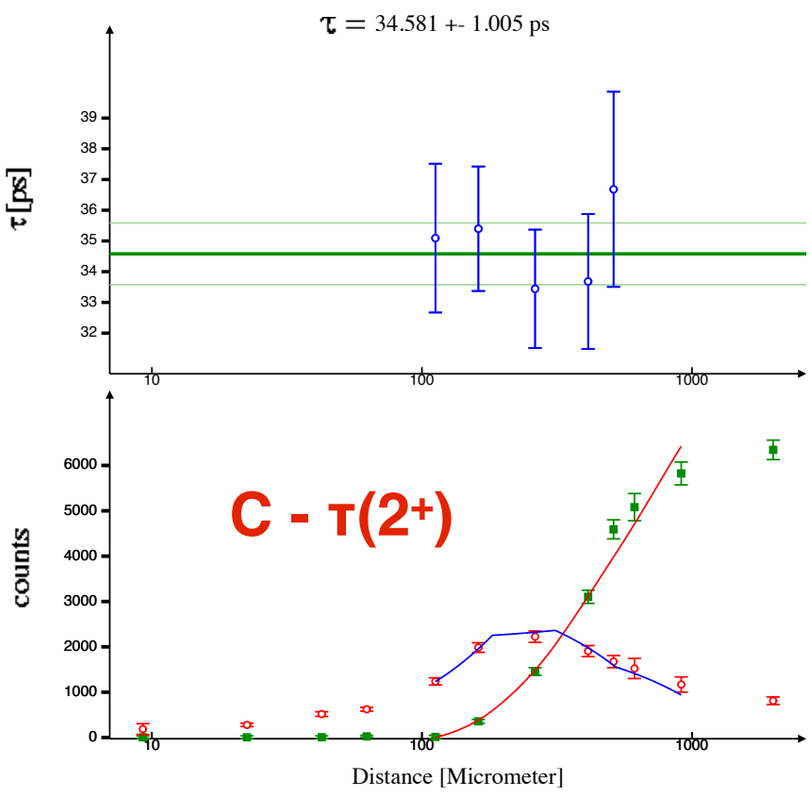
- Statistical error only, including normalisation of the distances

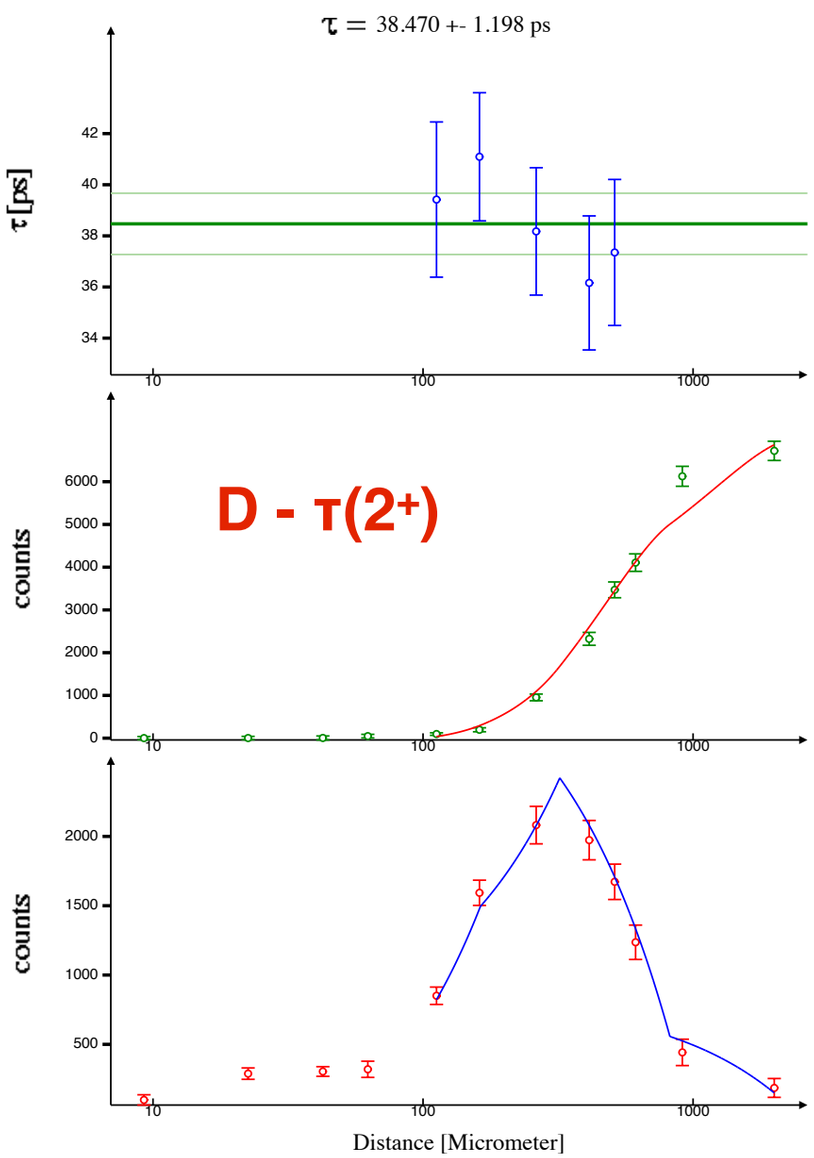
- Can be done for each ‘ring’ semi-independently (7 lifetimes)



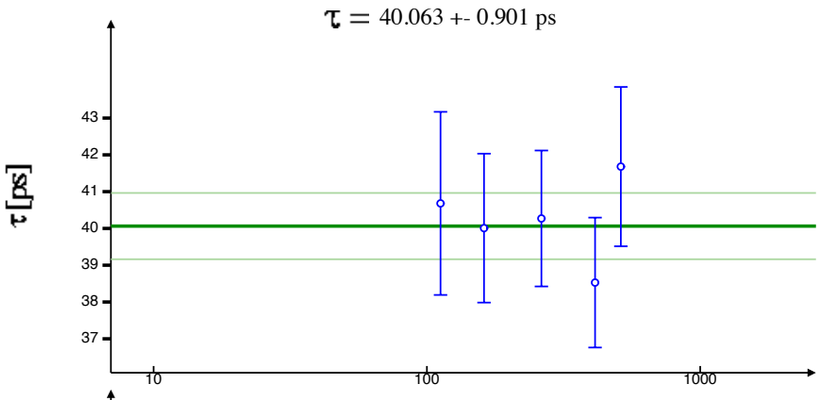
^{184}Hg - Lifetimes (2$^+$)

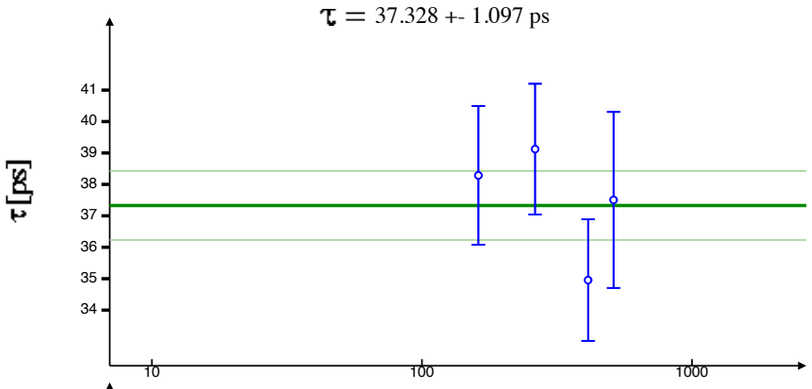


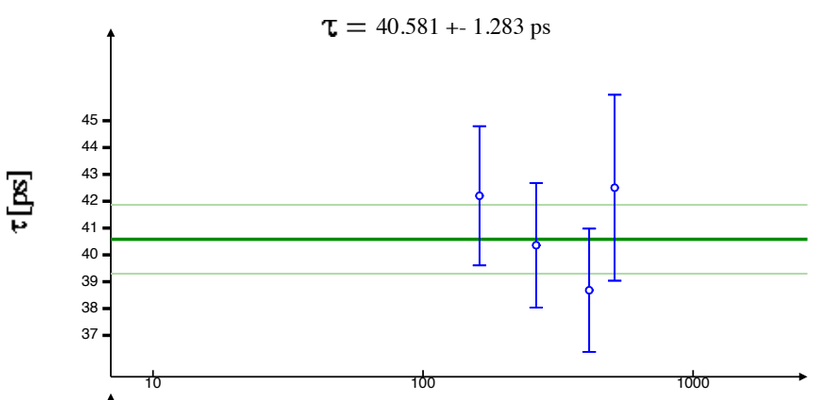


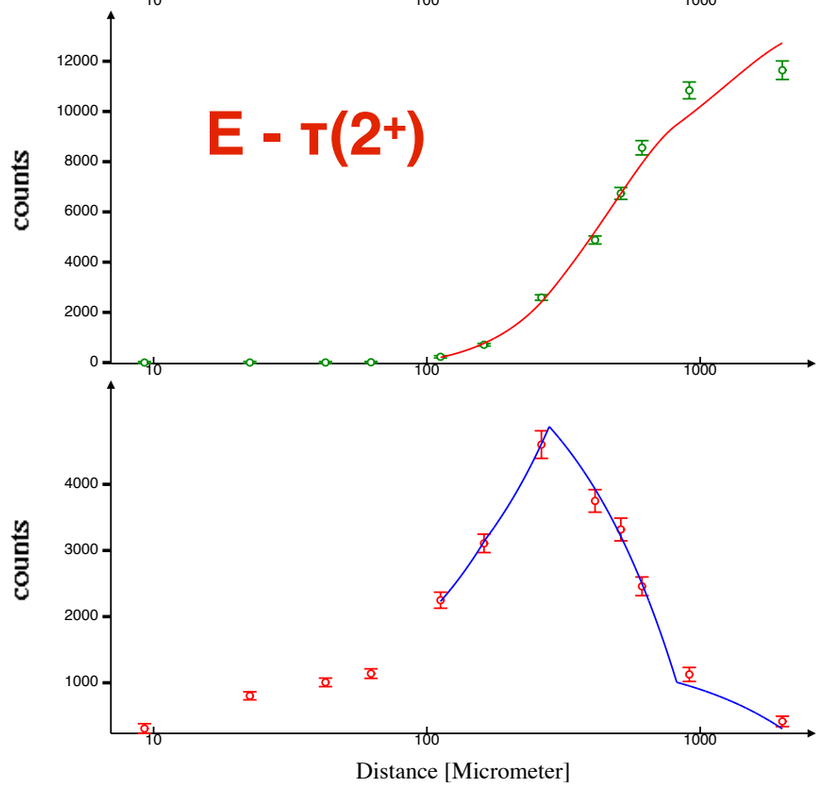


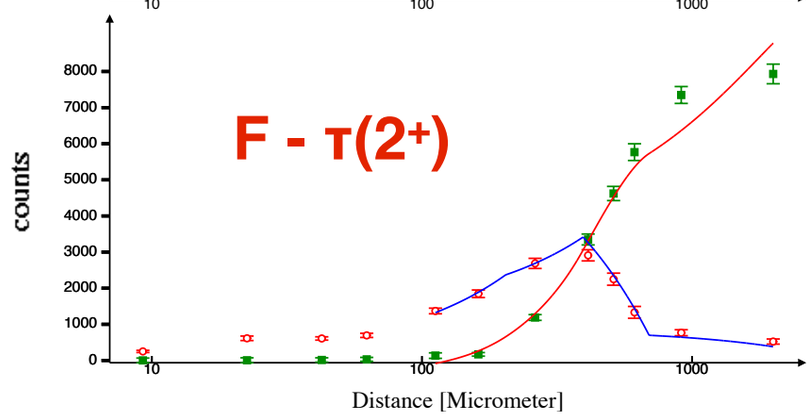
^{184}Hg - Lifetimes (2$^+$)

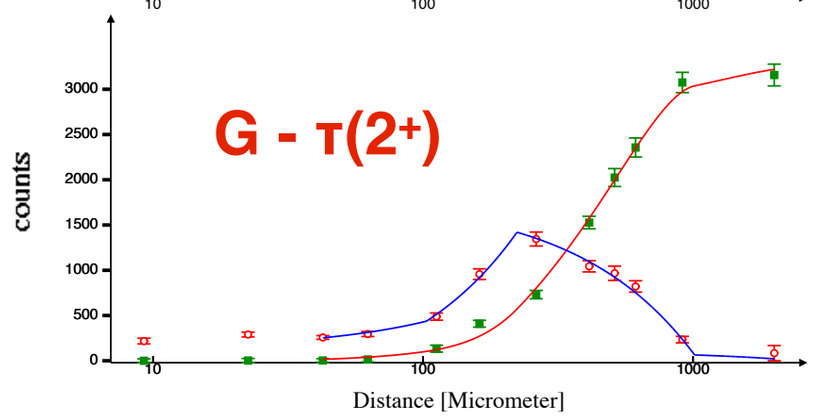










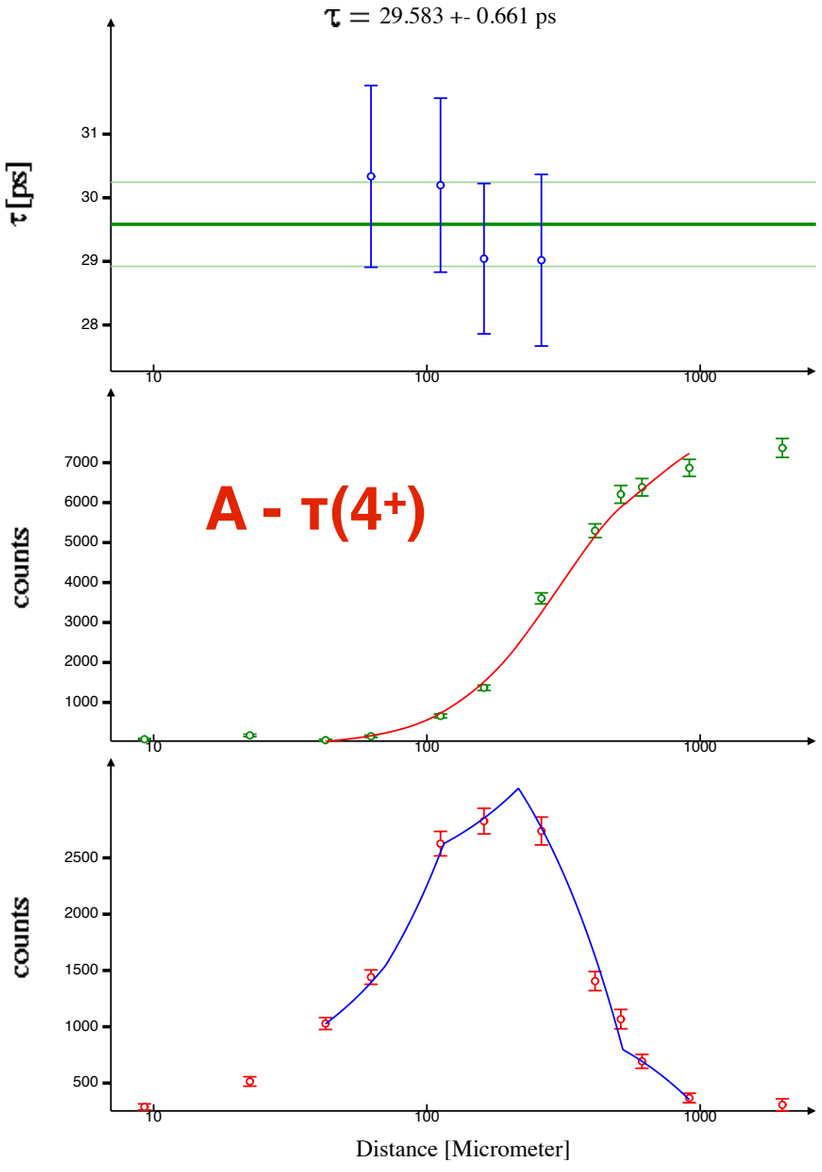


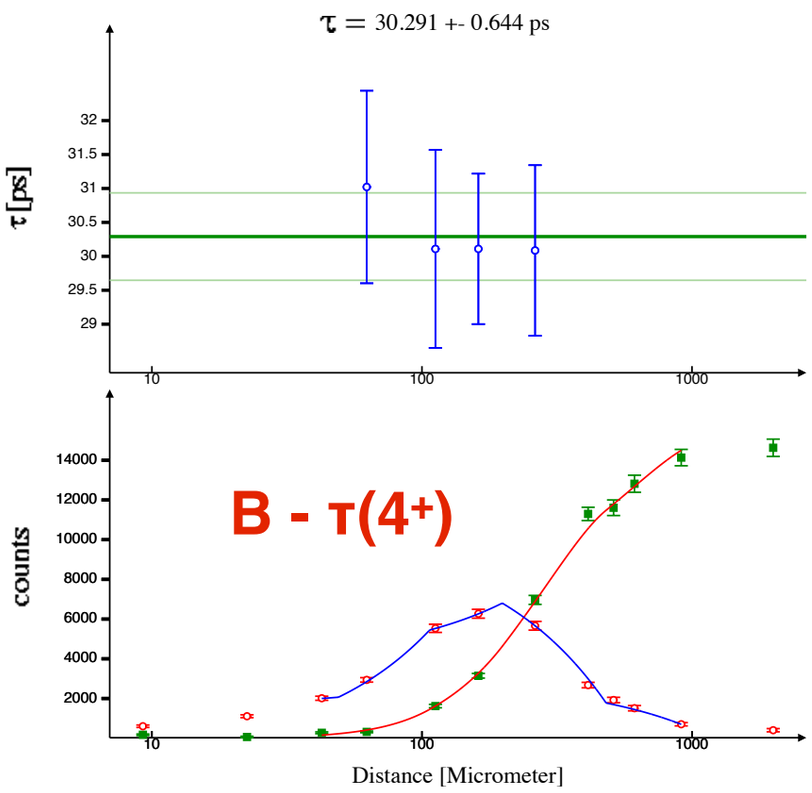
τ(2$^+$) weighted mean = (36.6 ± 3.0) ps

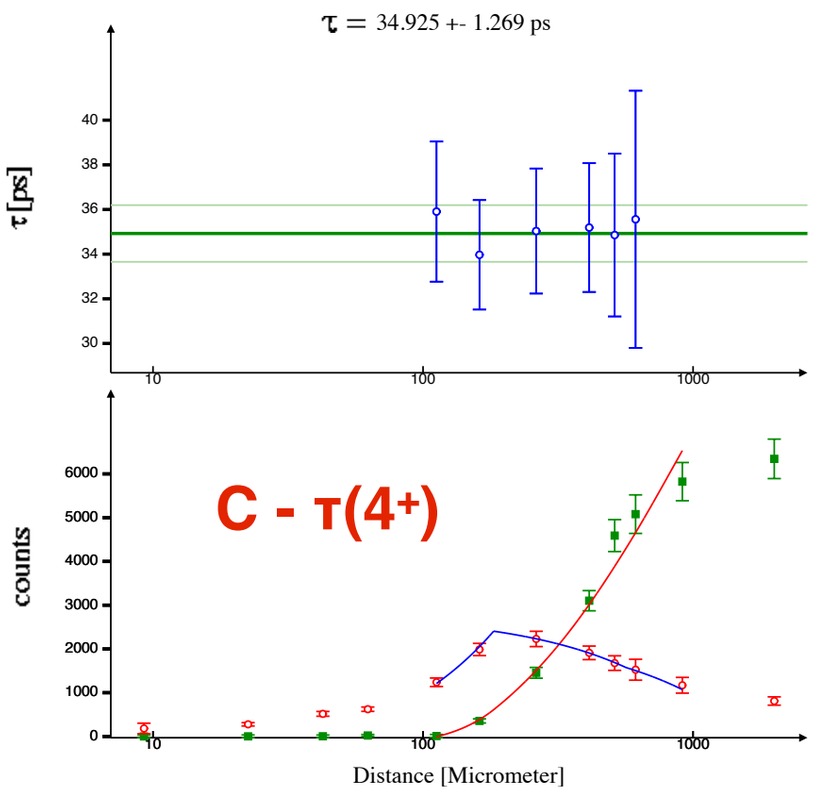
$| < 0^+ || E2 || 2^+ > |$ = (1.26 ± 0.05) eb

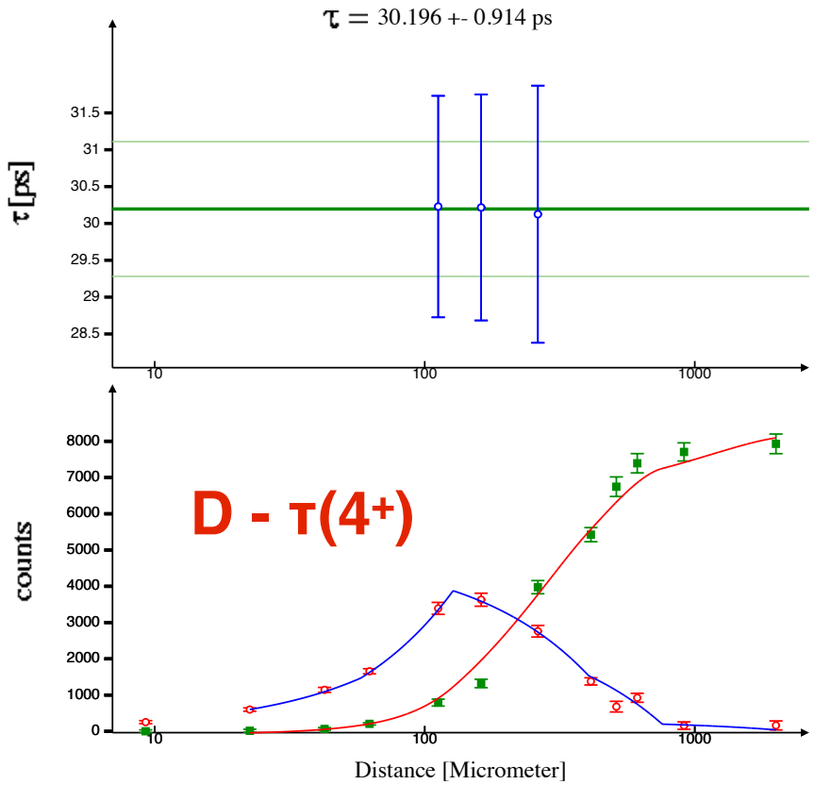
B(E2; 2$^+$ → 0$^+$) = (51 ± 4) W.u.

^{184}Hg - Lifetimes (4$^+$)

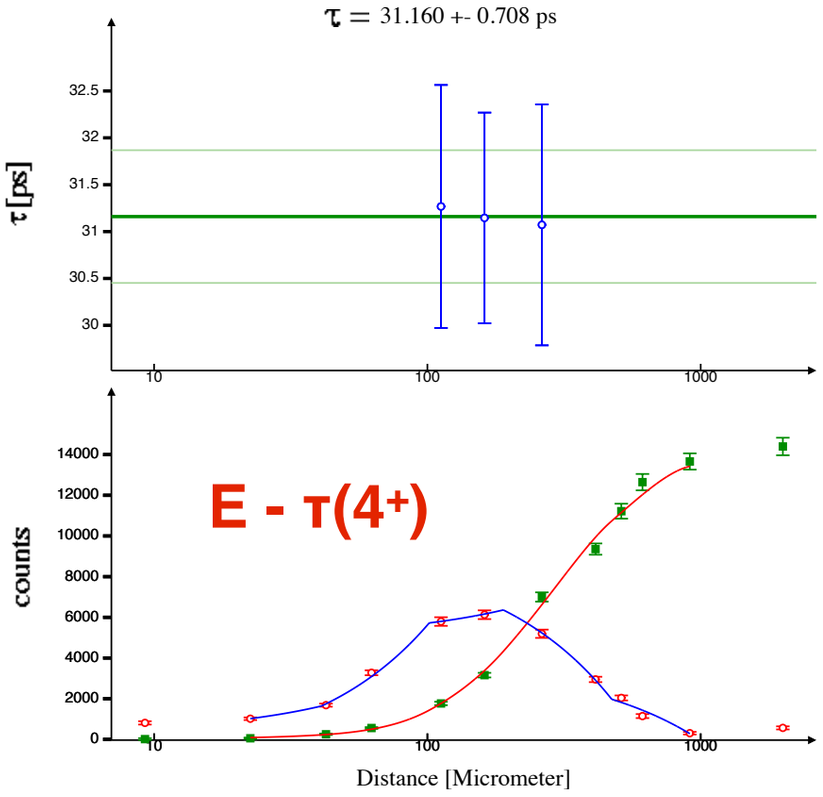


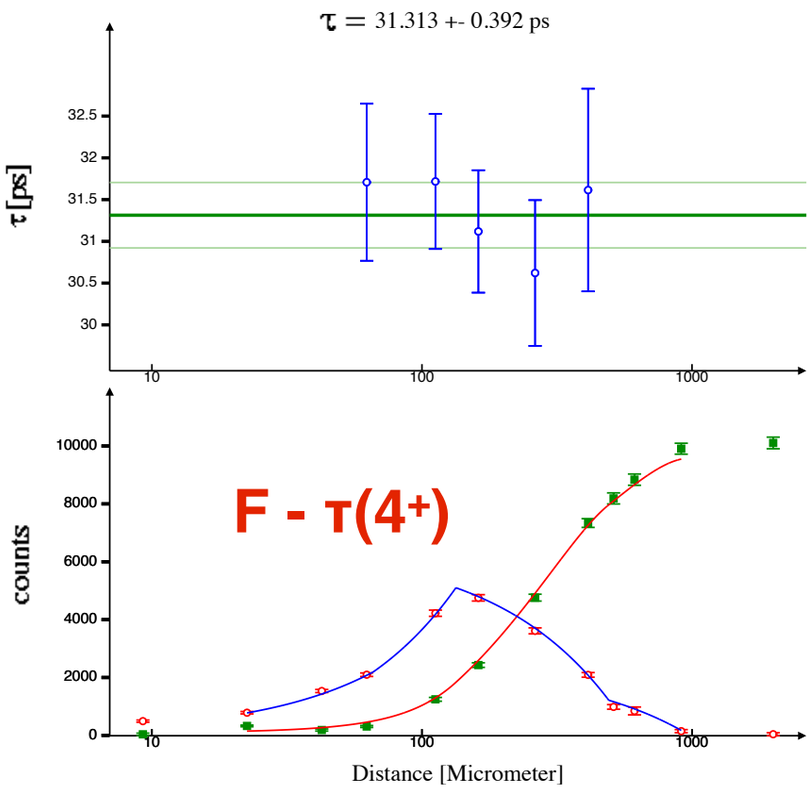


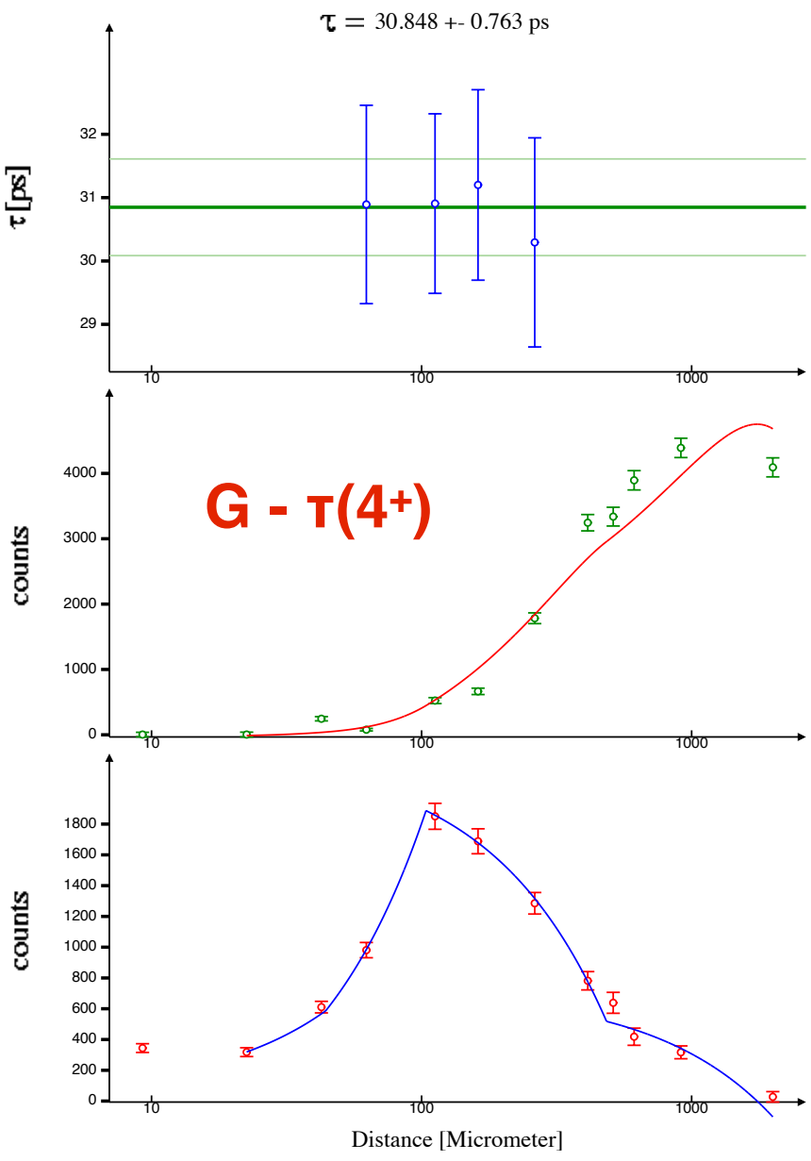




^{184}Hg - Lifetimes (4+)





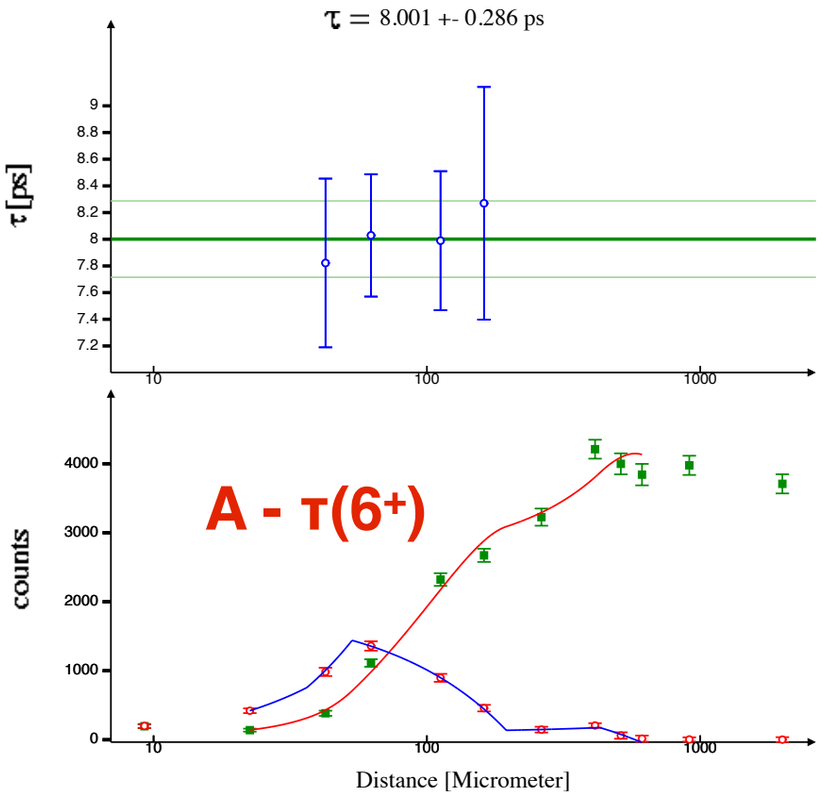


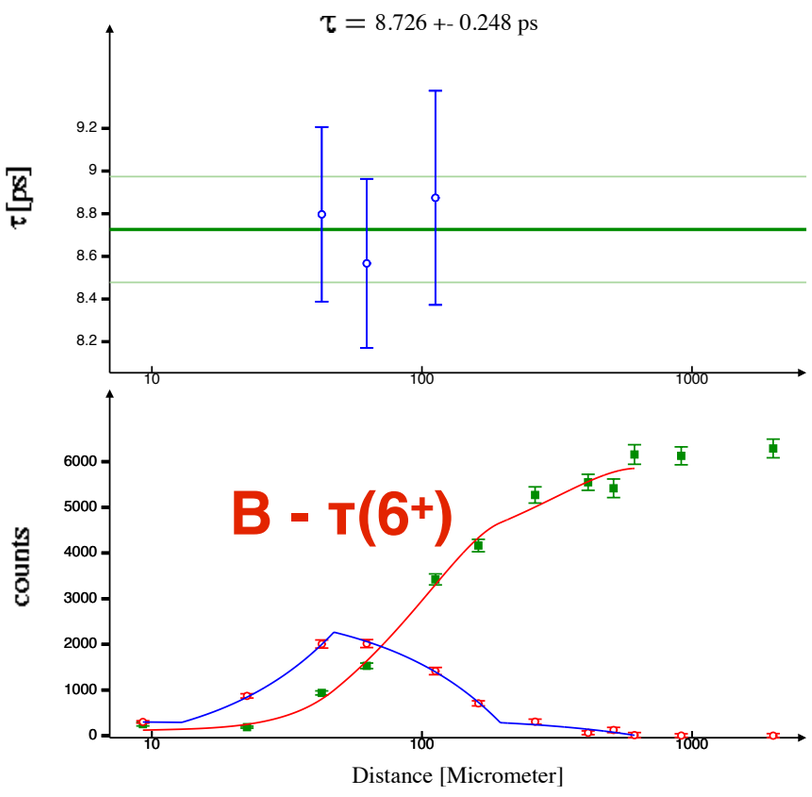
τ(4+) weighted mean = (30.7 ± 1.0) ps

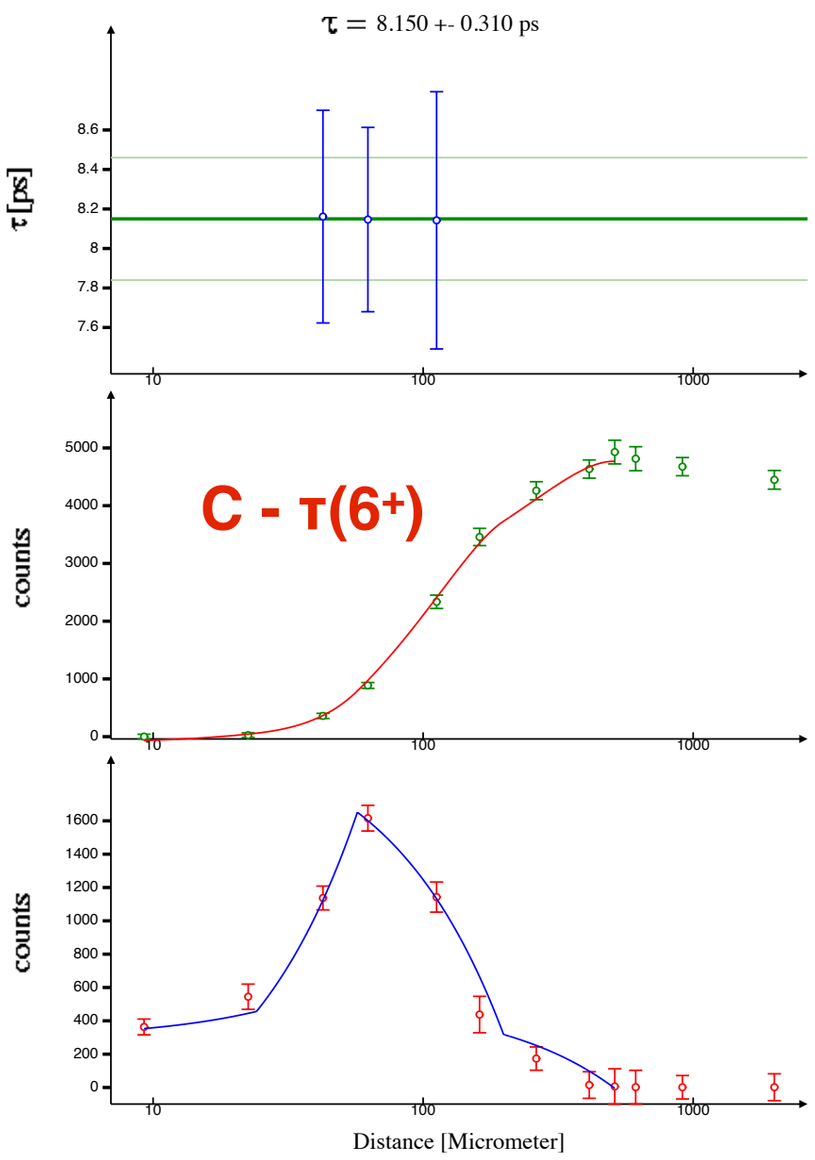
$| < 2^+ || E2 || 4^+ > |$ = (3.24 ± 0.05) eb

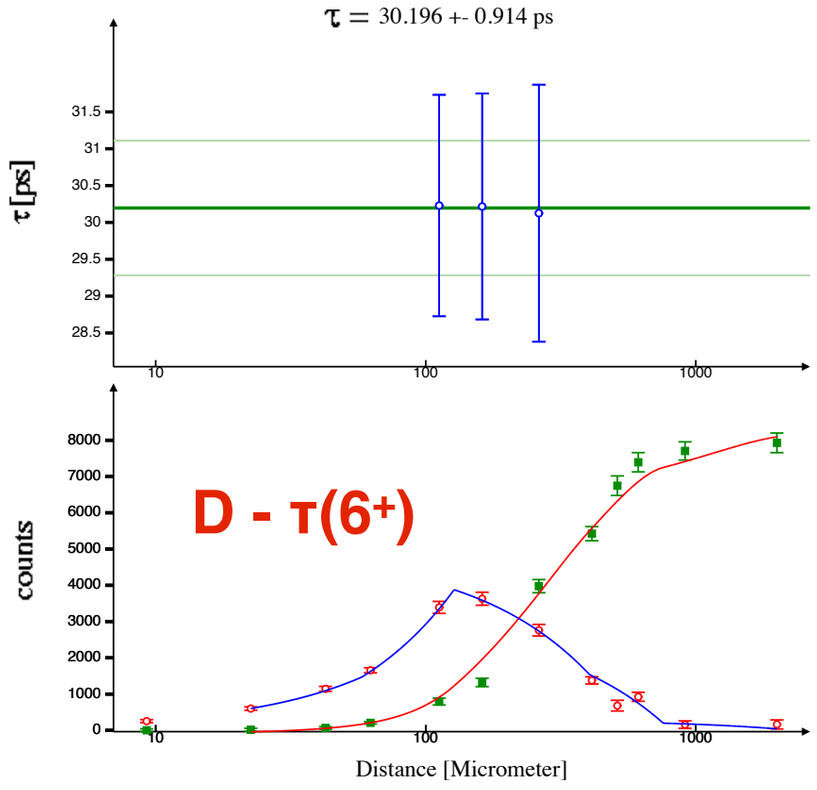
B(E2; 4+ → 2+) = (188 ± 6) W.u.

^{184}Hg - Lifetimes (6$^+$)

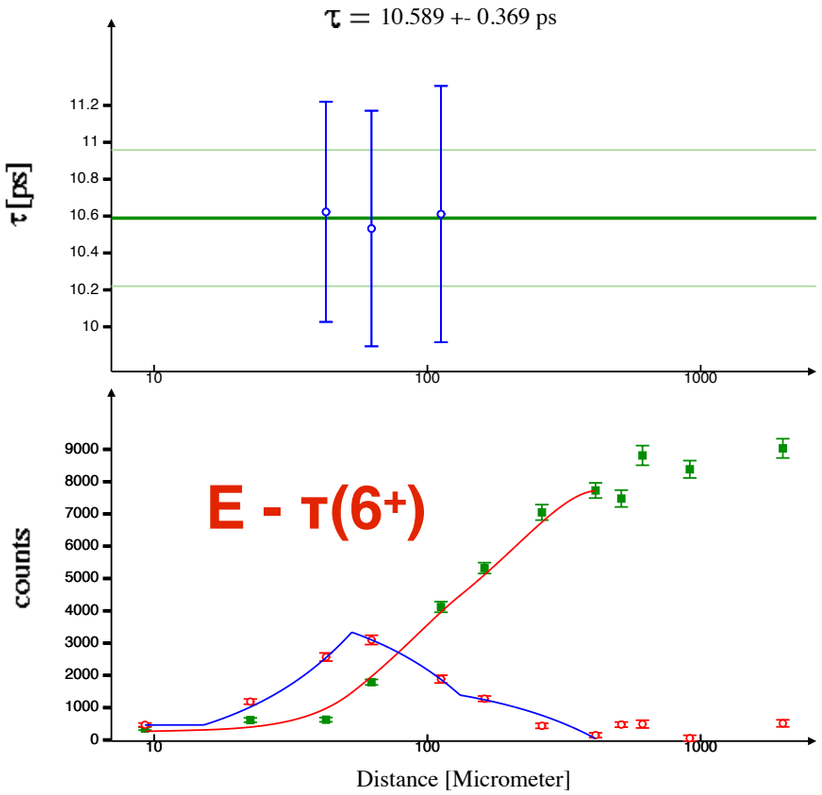


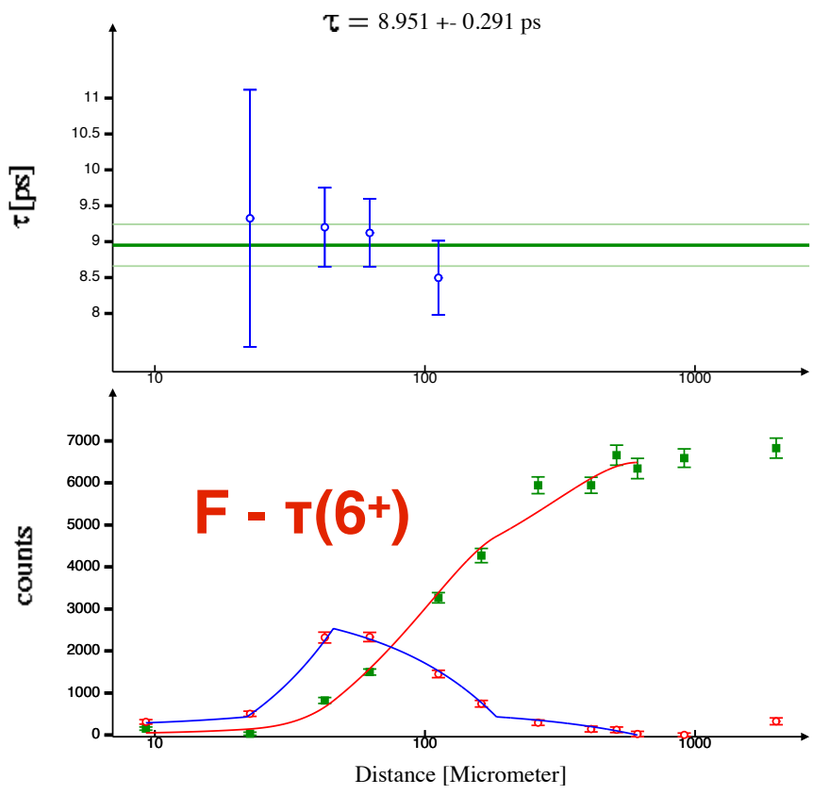


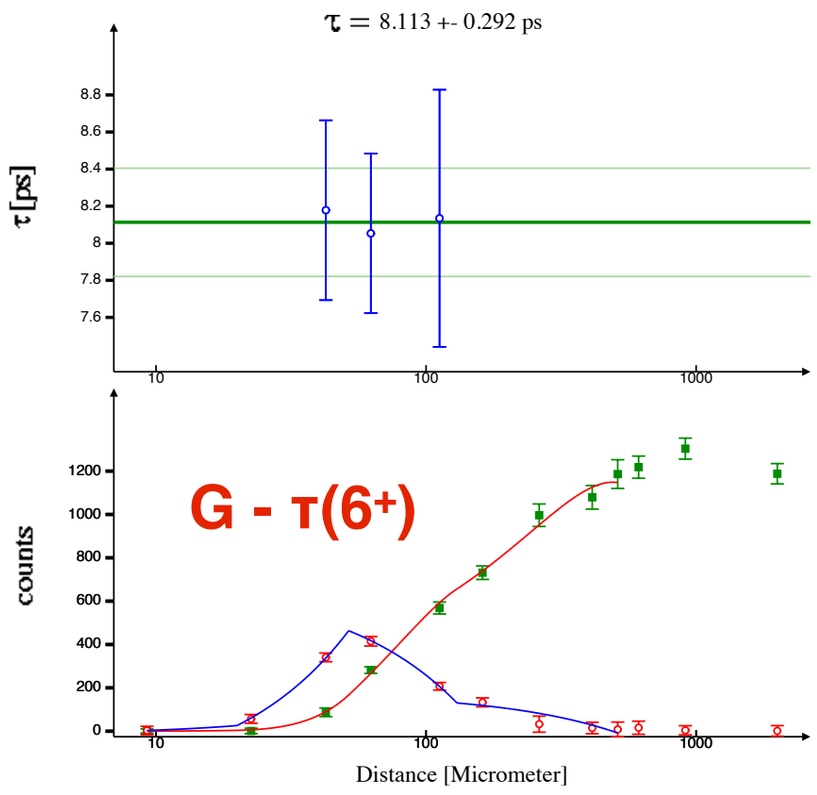




^{184}Hg - Lifetimes (6$^+$)





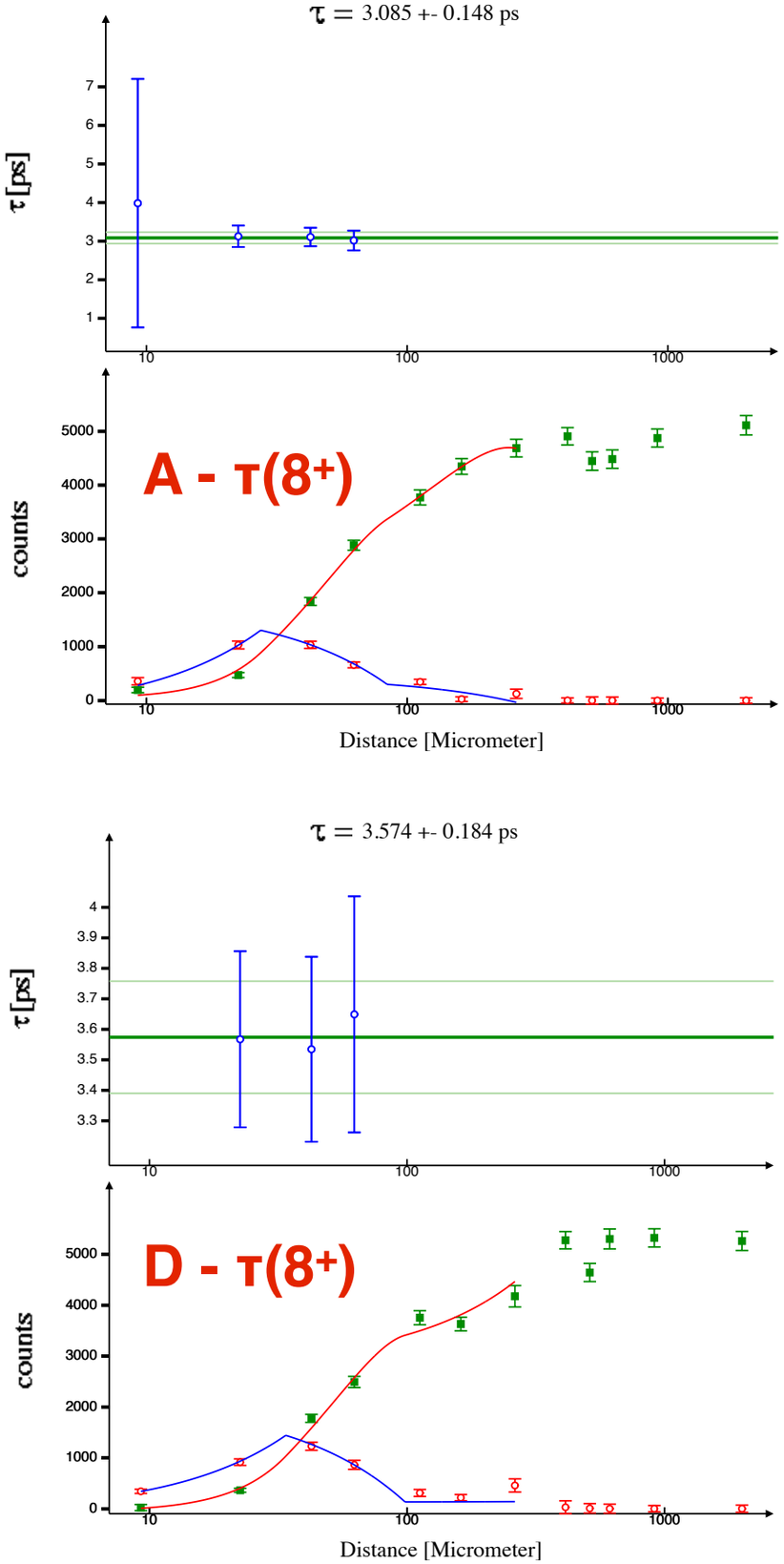


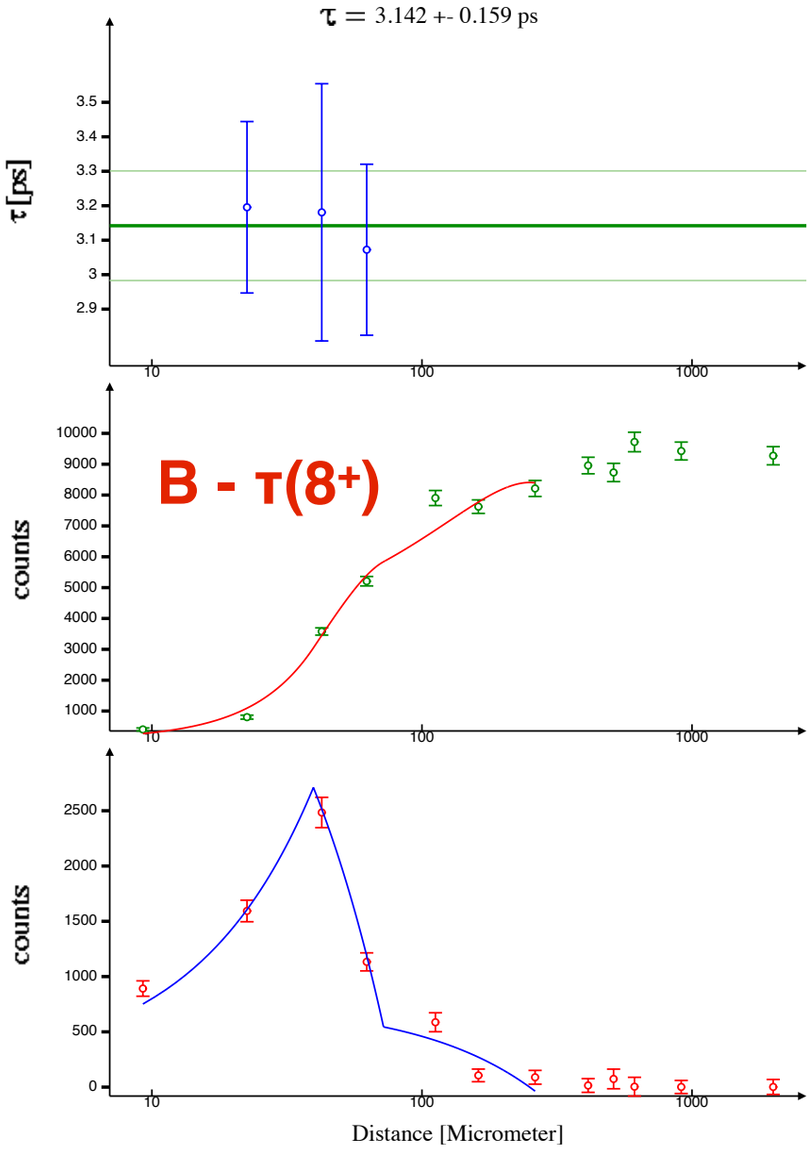
τ(6$^+$) weighted mean = (9.0 ± 1.3) ps

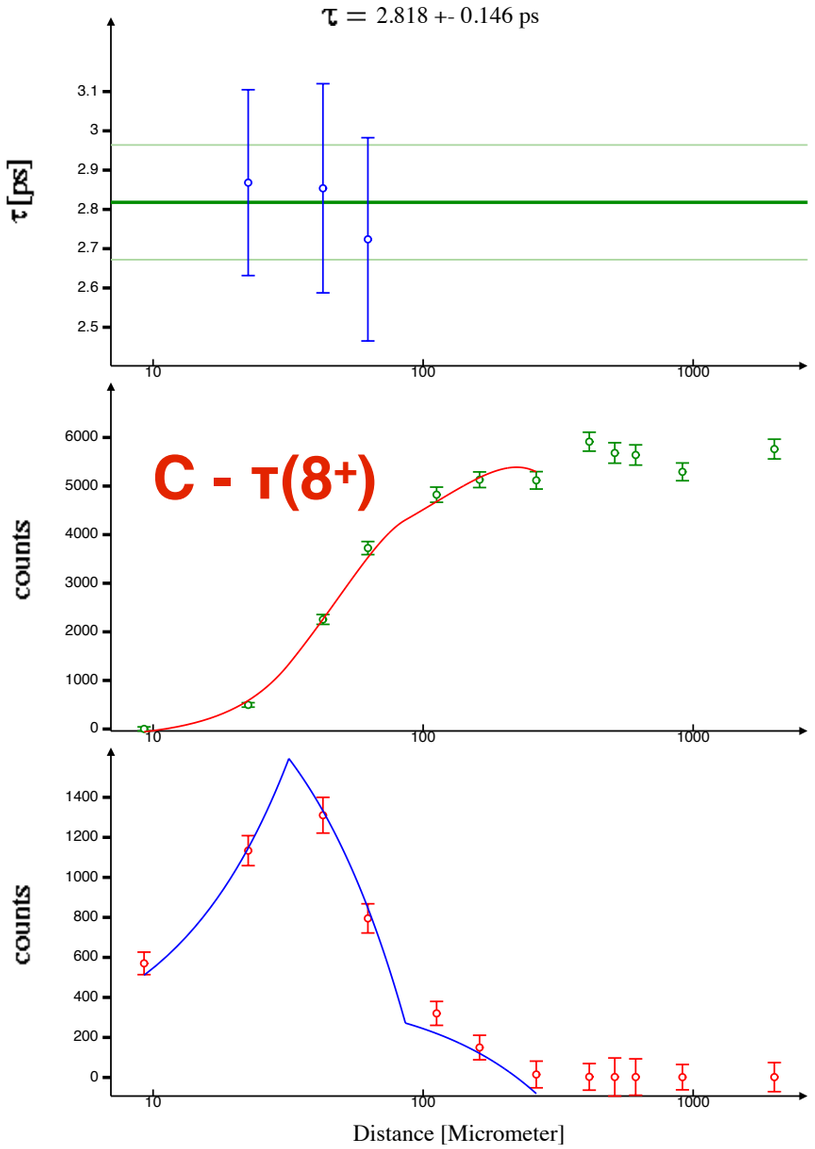
$|<4^+||E2||6^+>|$ = (4.9 ± 0.4) eb

B(E2; 6$^+$ → 4$^+$) = (300 ± 40) W.u.

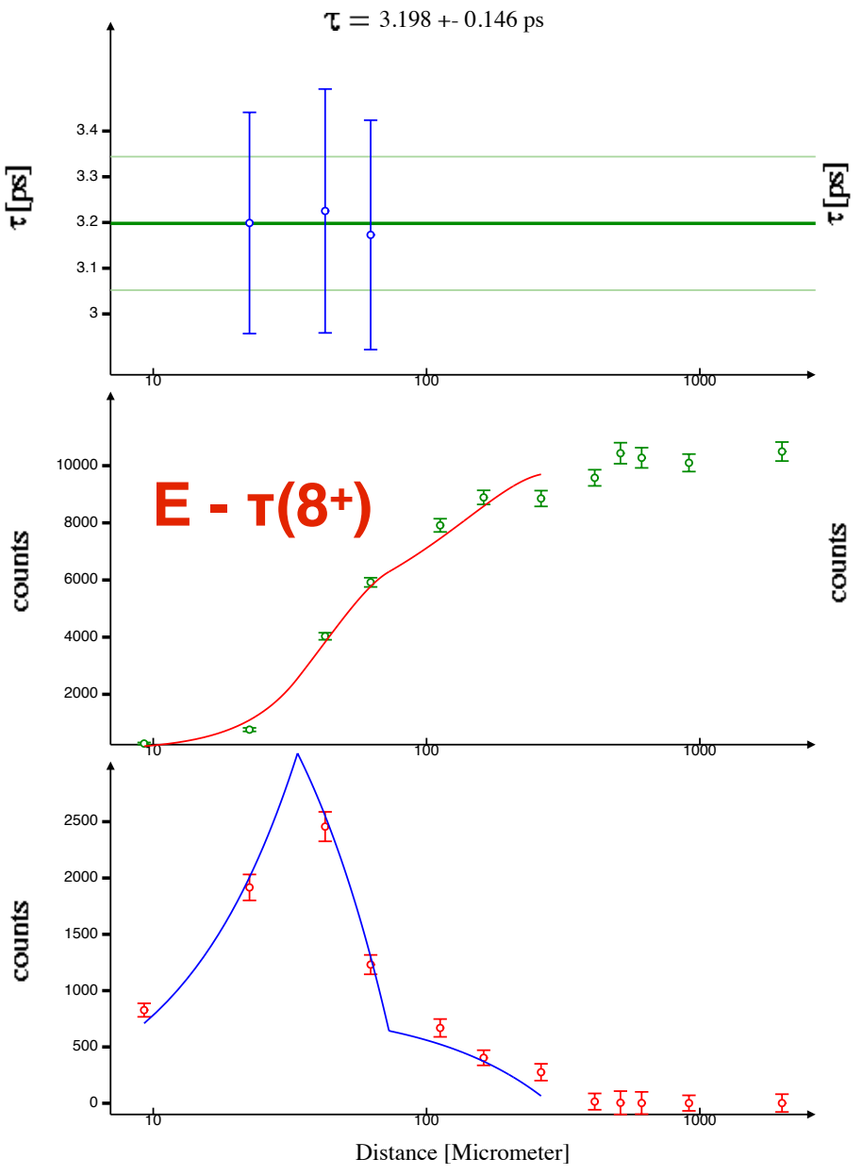
^{184}Hg - Lifetimes (8$^+$)

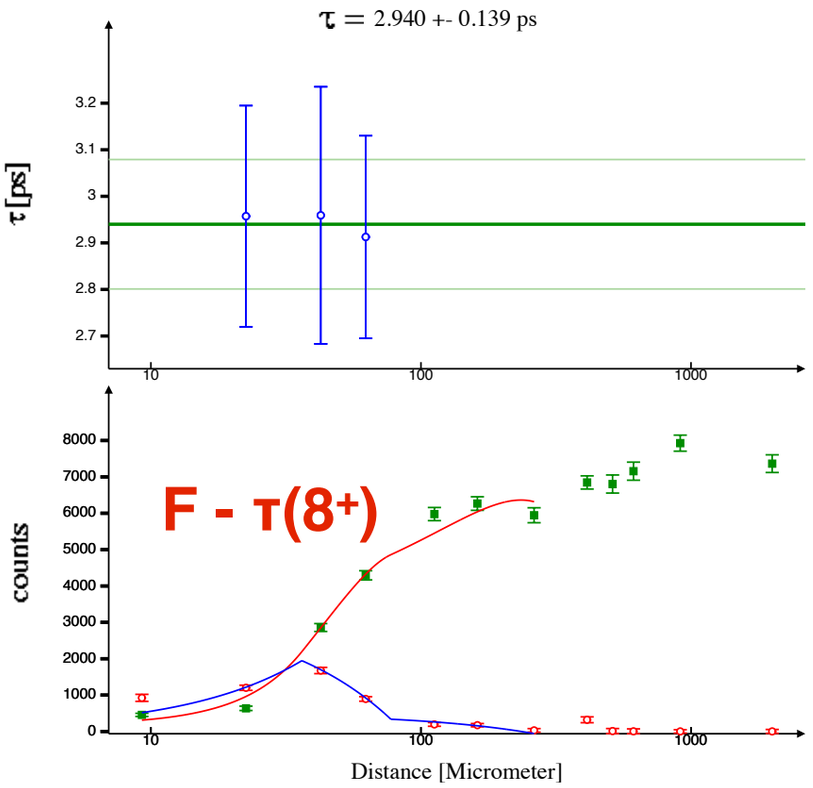


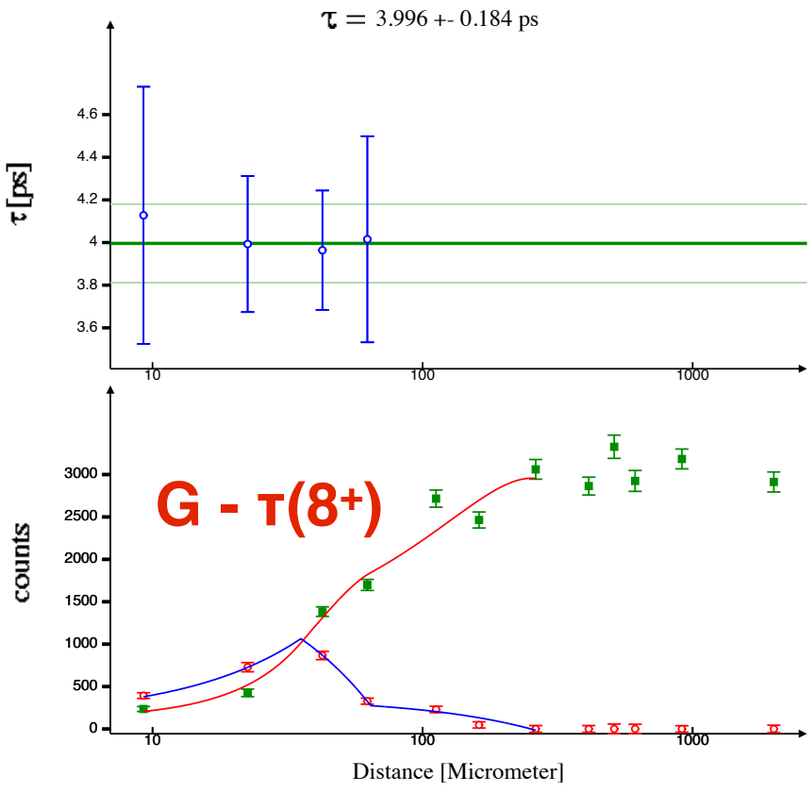




^{184}Hg - Lifetimes (8$^+$)







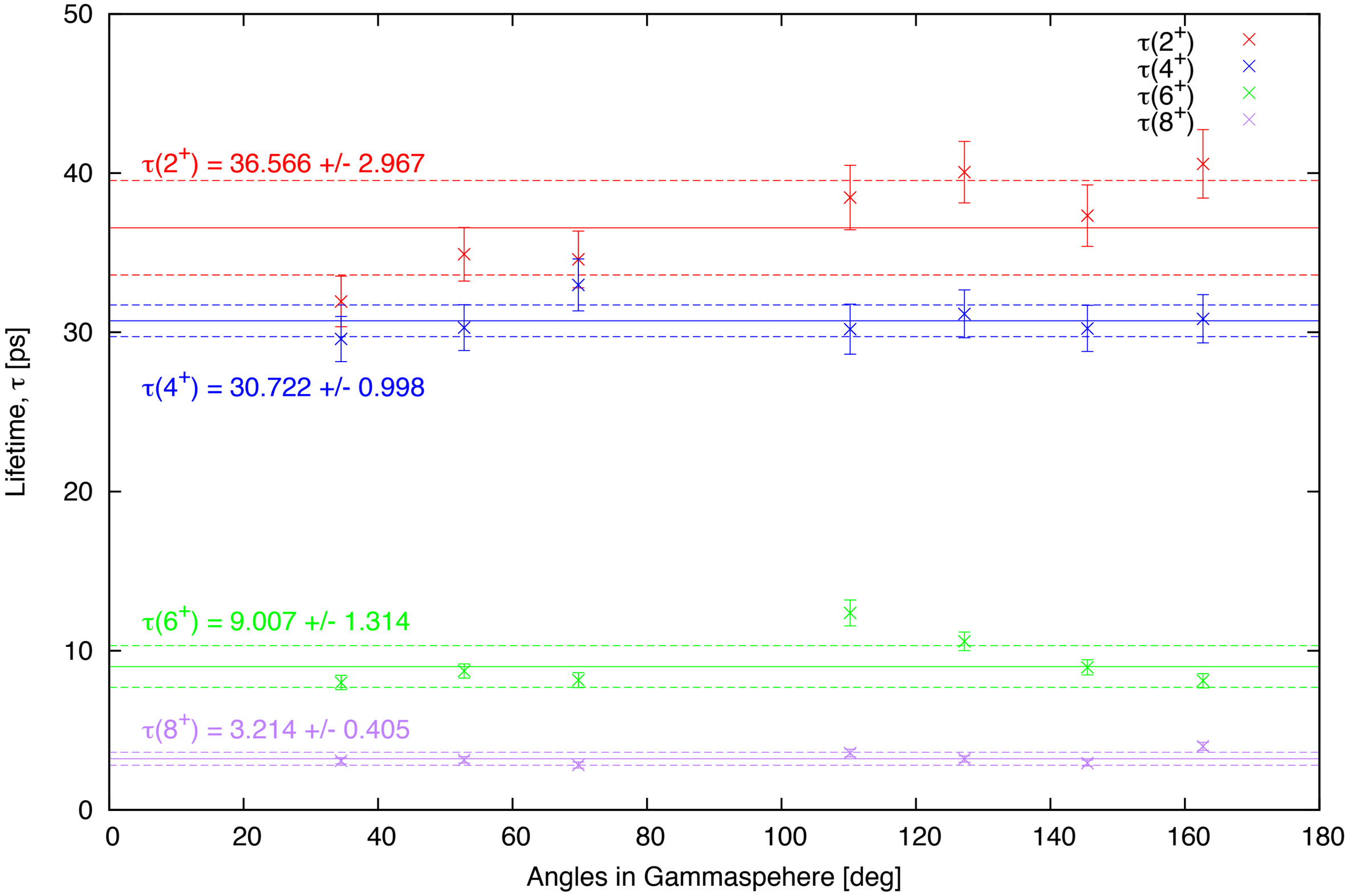
τ(8$^+$) weighted mean = (3.2 ± 0.4) ps

$| < 6^+ || E2 || 8^+ > |$ = (5.7 ± 0.4) eb

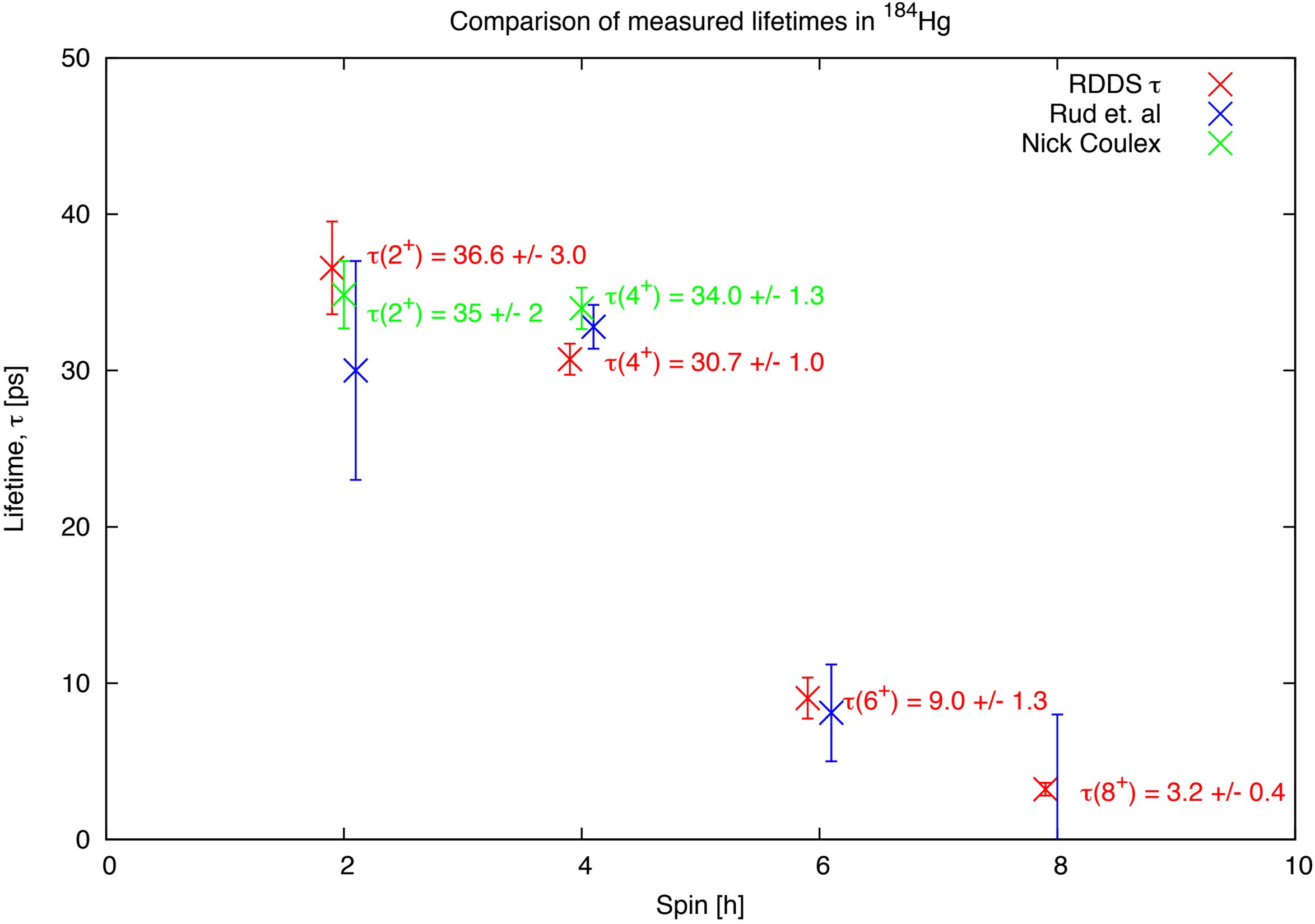
B(E2; 8$^+$ → 6$^+$) = (310 ± 30) W.u.

^{184}Hg - Lifetimes

RDDS lifetimes in ^{184}Hg measured with Gammasphere and the Koln plunger using the DDCM method



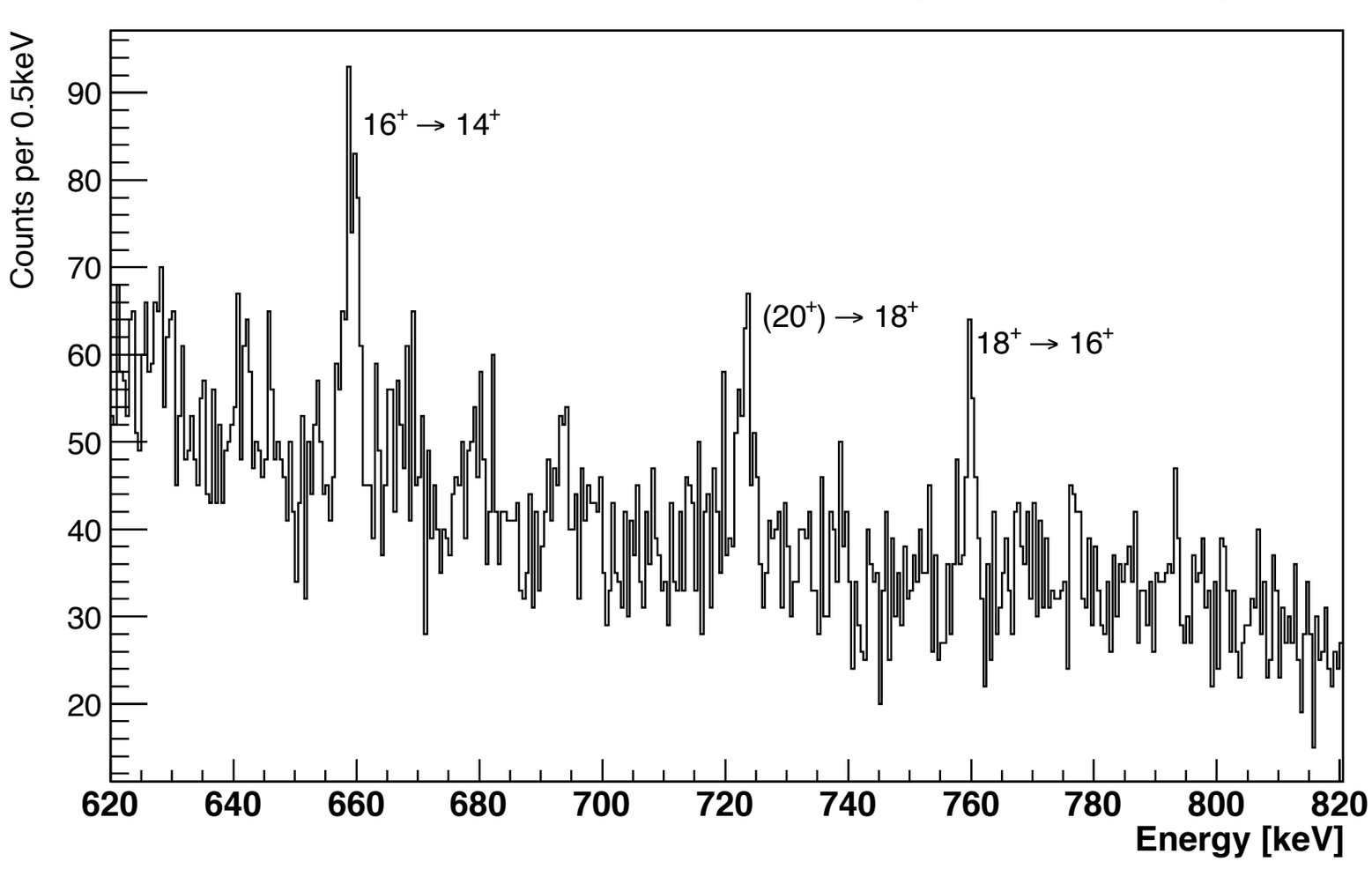
^{184}Hg - Lifetimes



^{188}Hg - Contaminated!

- 134ns ($I^{\pi}=12^{+}$) isomer at 2.7MeV --> **d > 8m**
- 5n and 6n channels cause contamination with similar γ-ray energies
-

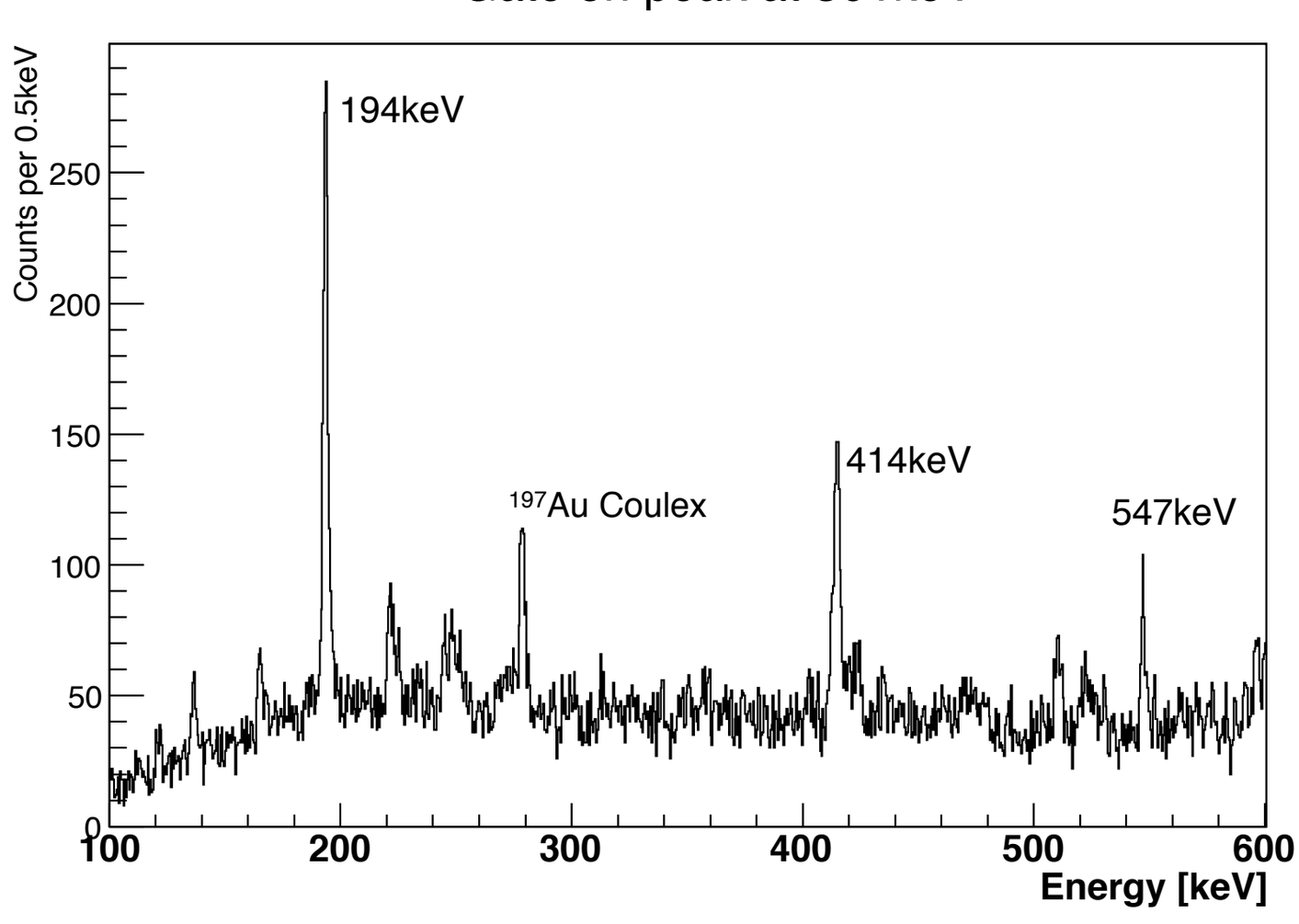
Gate on $14^{+}\rightarrow12^{+}$ transition feeding isomer in ^{188}Hg



^{188}Hg - Contaminated!

- 134ns ($I^{\pi}=12^{+}$) isomer at 2.7MeV --> **d > 8m**
- 5n and 6n channels cause contamination with similar γ-ray energies
- Other strong channels less of a direct problem in coincidence

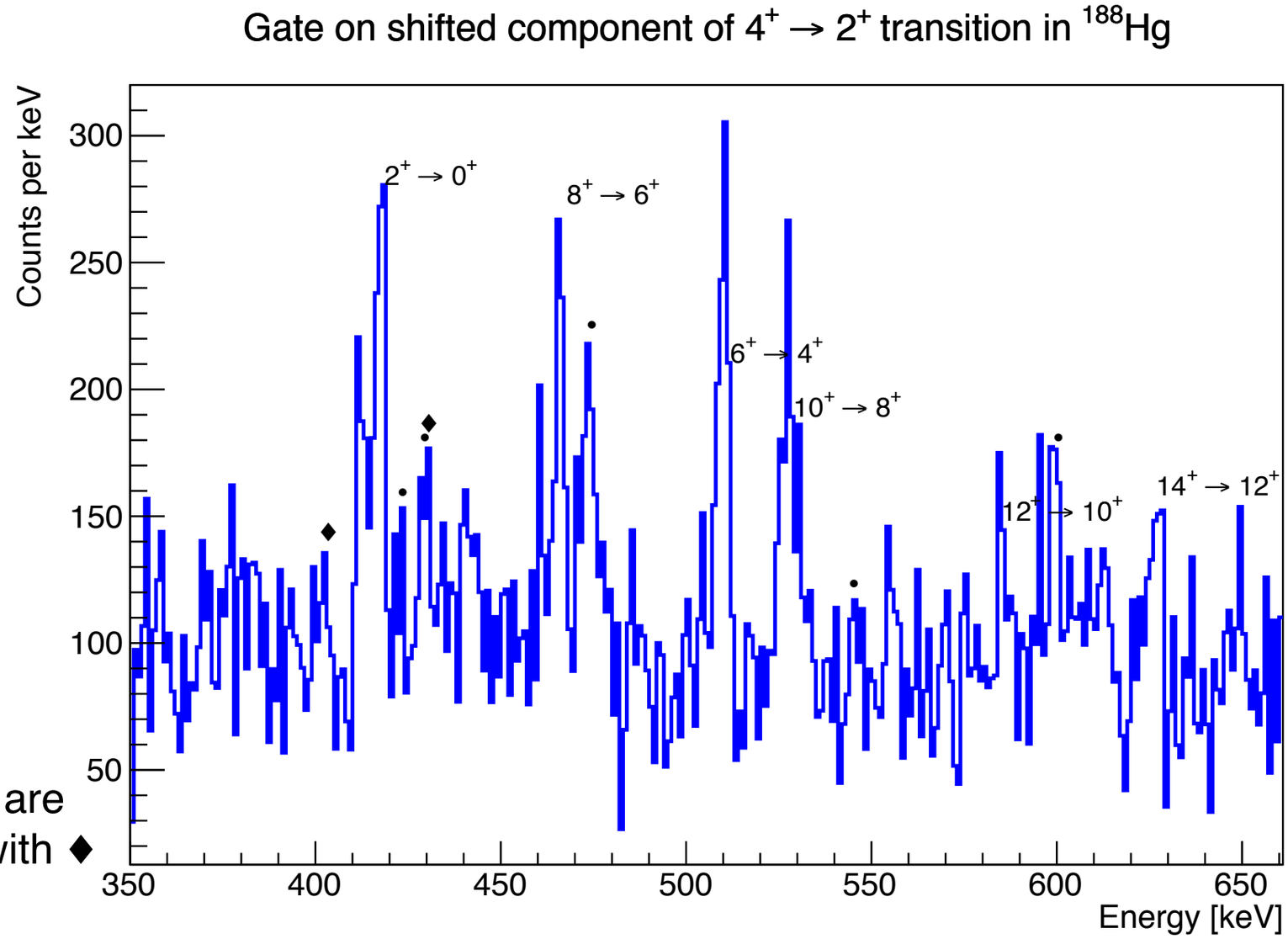
Gate on peak at 301keV



^{188}Hg - Contaminated!

- 134ns ($I^{\pi}=12^{+}$) isomer at 2.7MeV --> **d > 8m**
- 5n and 6n channels cause contamination with similar γ-ray energies
- Other strong channels less of a direct problem in coincidence
- Cleanest and widest possible gate on $(4^{+} \rightarrow 2^{+})_{sh}$
- Unidentified lines present along with lines in ^{187}Hg and ^{186}Hg.
- τ fits are inconsistent vs angle or if gates or changed
- Sum gate not possible either

known transitions in ^{187}Hg are marked with • and ^{186}Hg with ♦



^{184}Hg

Level scheme from:
Deng *et al.* Phys. Rev. C **52** (1995) 595

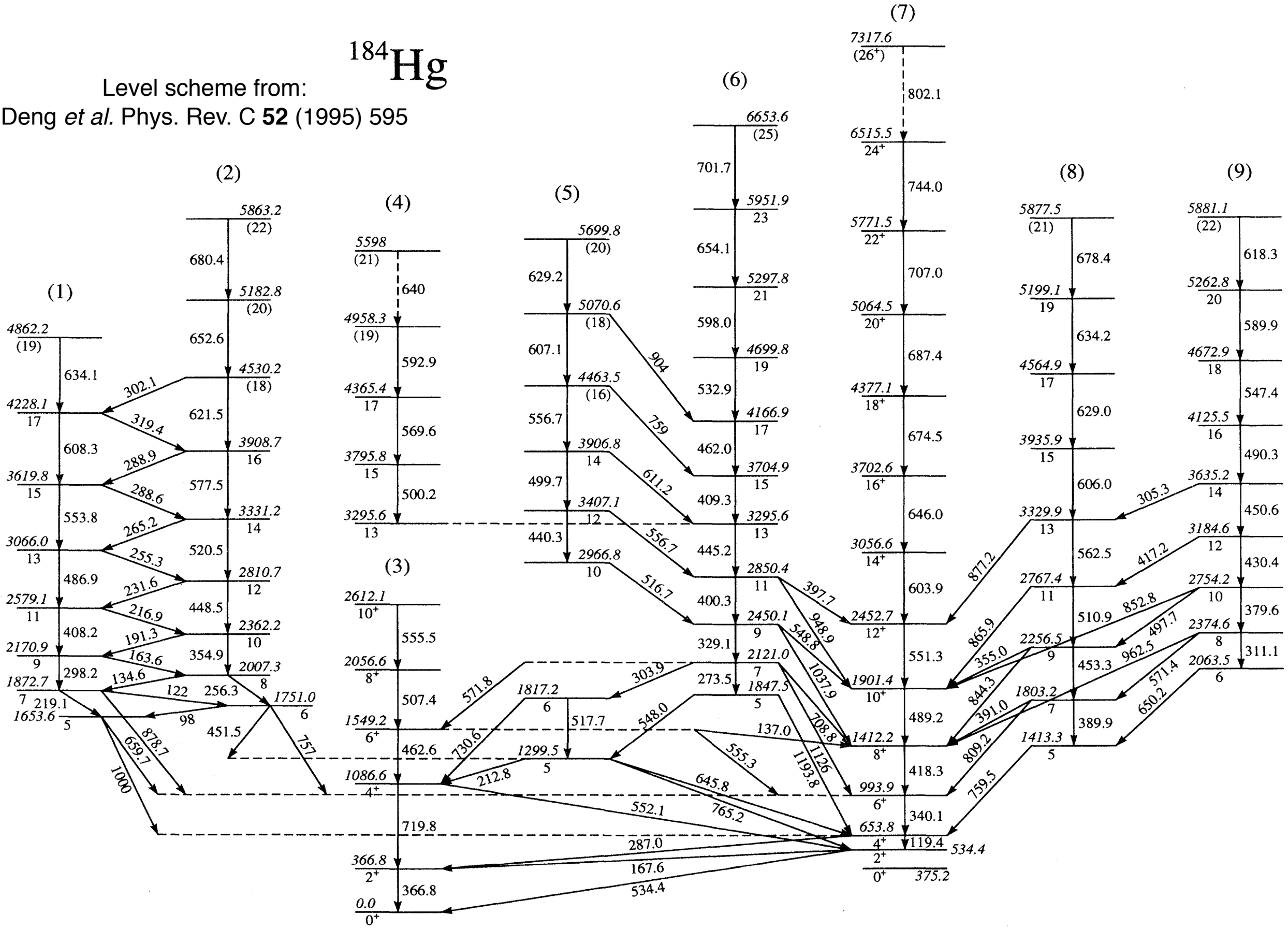


FIG. 1. Proposed level scheme for ^{184}Hg.

Level scheme from:
F. Hannaci *et al.* Nucl. Phys. A **481** (1988) 135