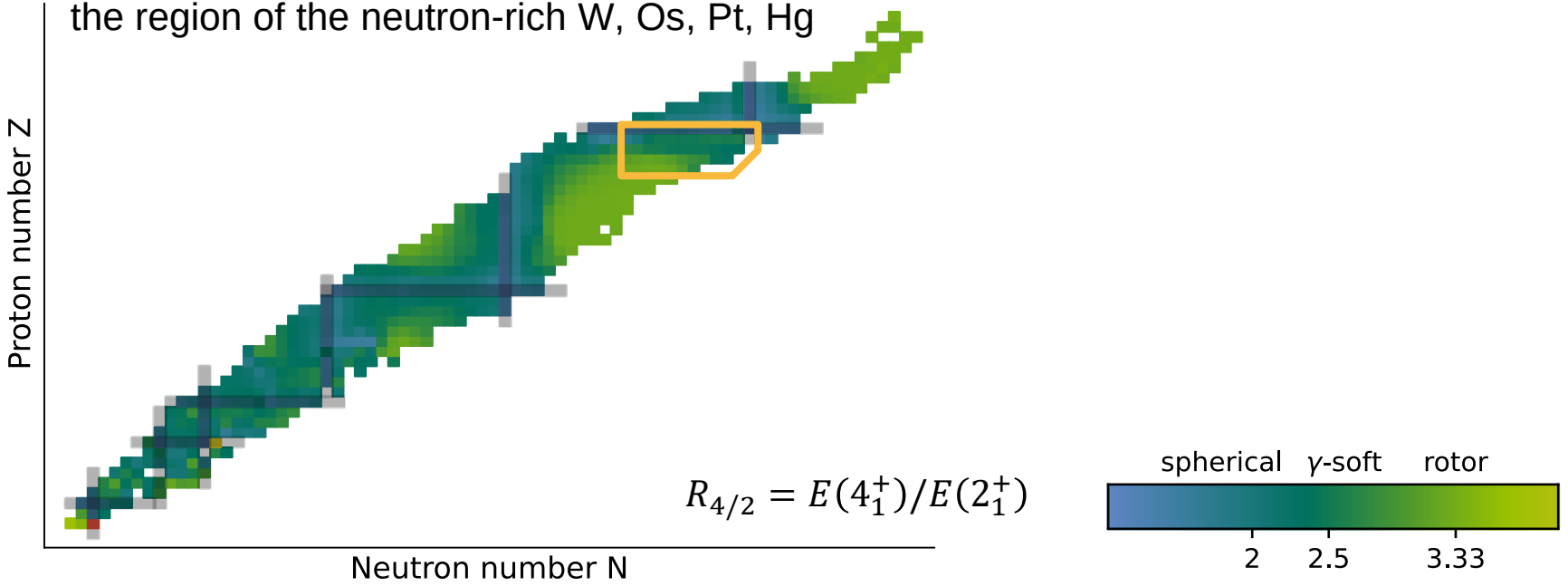
First measurement of the lifetime of the 2^+_1 state of ^{200}Pt

International Symposium on Nuclear Science (ISNS-24)

TECHNISCHE UNIVERSITÄT DARMSTADT

Motivation

- shape transitions between rigid rotor, γ-soft and spherical occur in the region of the neutron-rich W, Os, Pt, Hg



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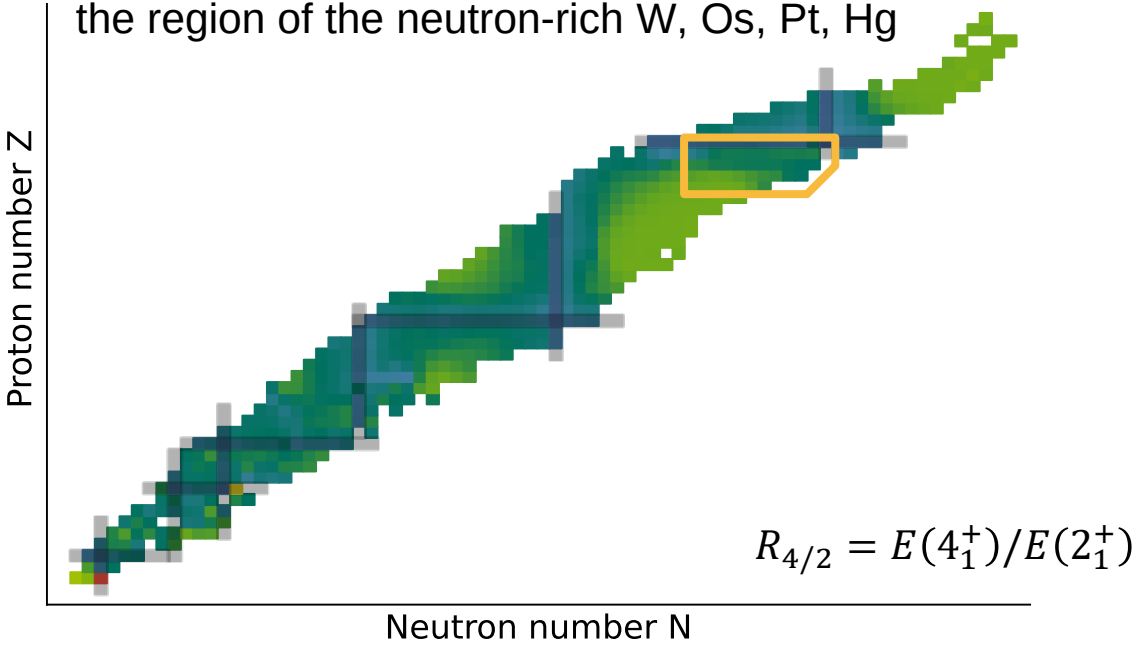
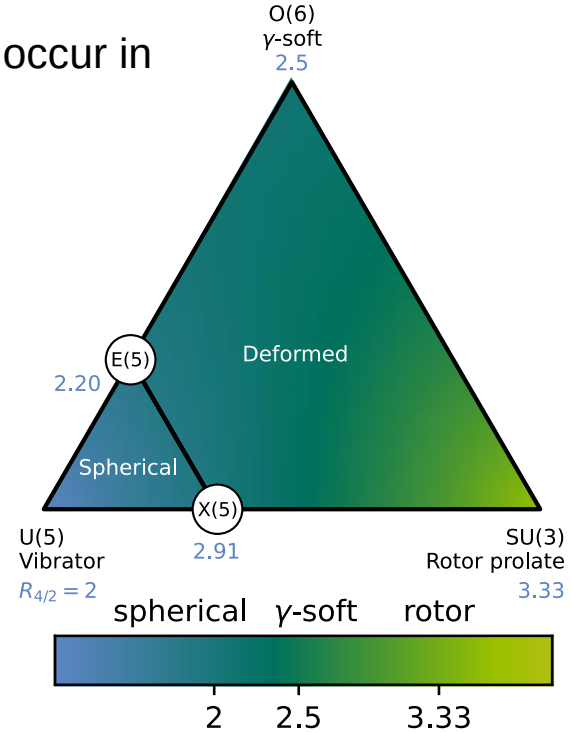


$$R_{4/2} = E(4_1^+)/E(2_1^+)$$



R.F. Casten, Nat. Phys. **2**.12, 812-820 (2006)

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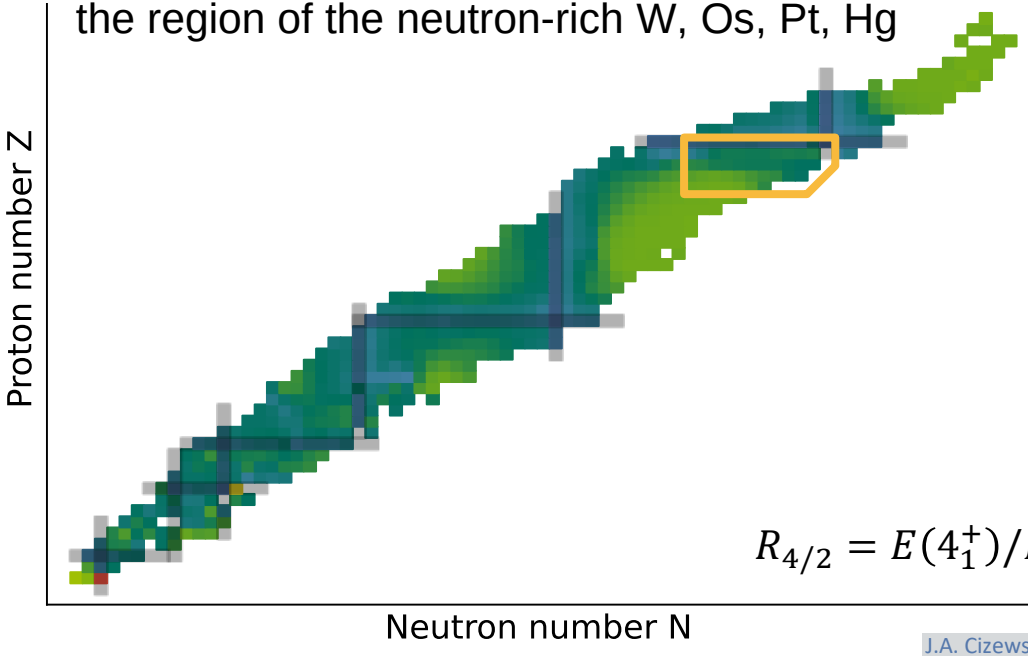

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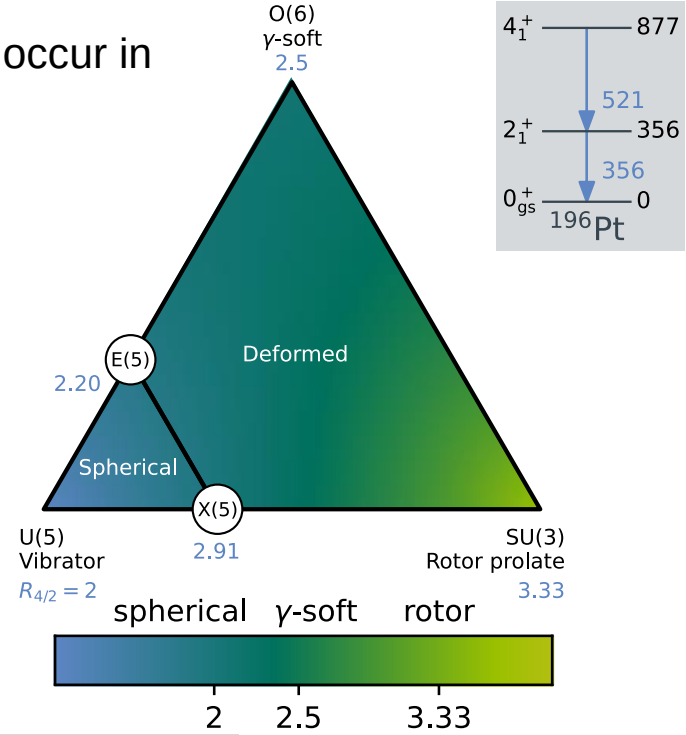
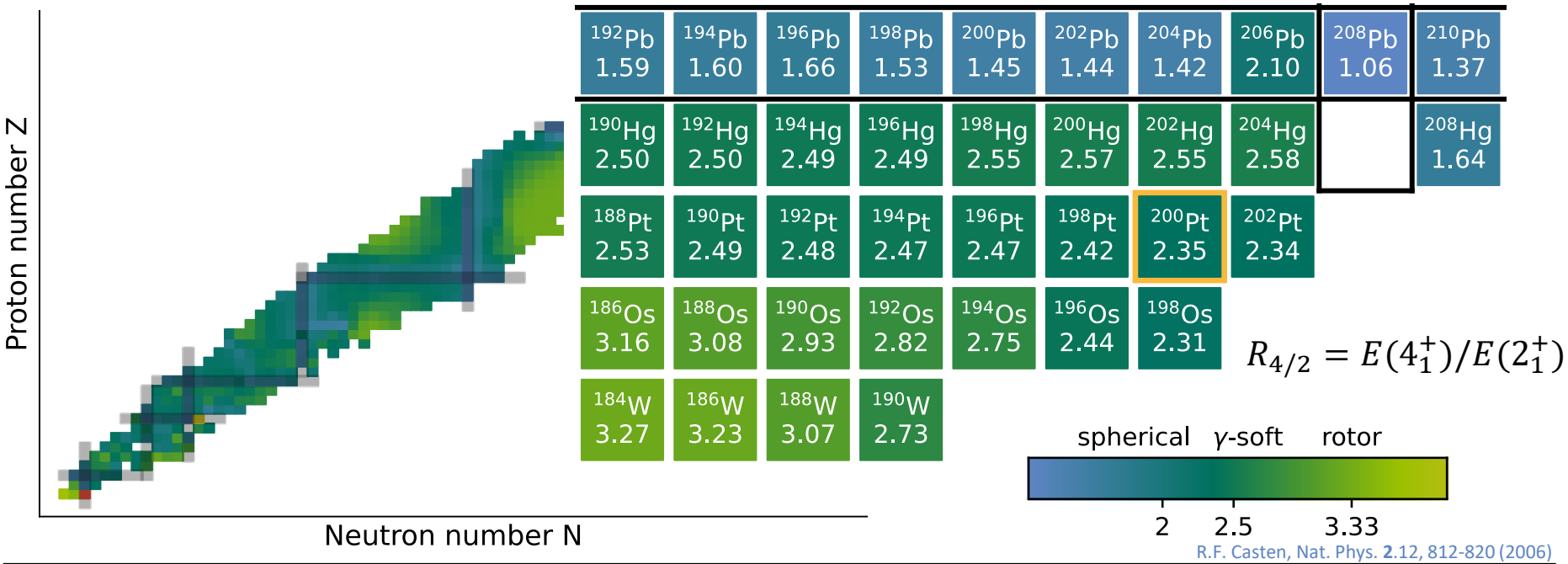


J.A. Cizewski *et al.*, Phys. Rev. Lett. **40**, 167 (1978) R.F. Casten, Nat. Phys. **2**.12, 812-820 (2006)

Motivation

- ^{200}Pt could mark transition between a γ-soft and spherical shape



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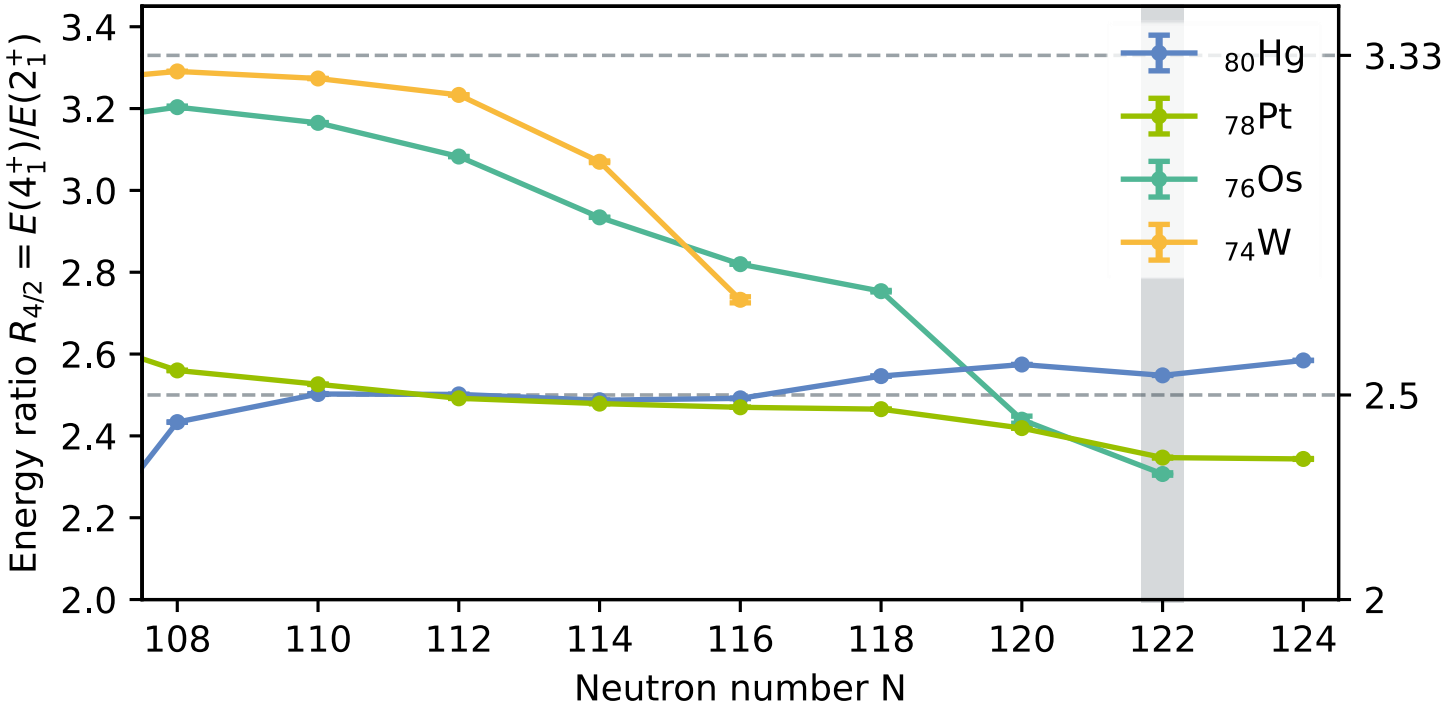
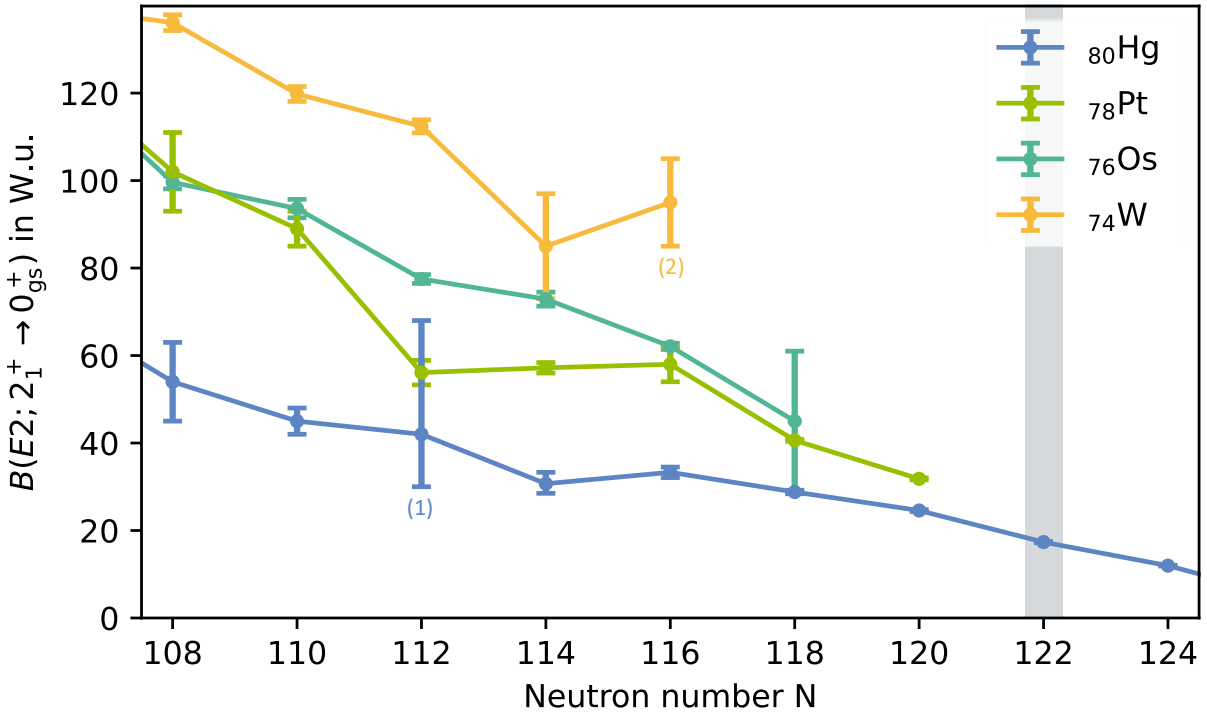


Data taken from NNDC

Motivation

- $B(E2; 2_1^+ \rightarrow 0_{gs}^+)$ quantifies quadrupole collectivity
- $B(E2) \sim 1/\tau(2_1^+)$
- $\tau(2_1^+; {}^{198}\mathrm{Pt}) = 22.25(15)\mathrm{ps}$

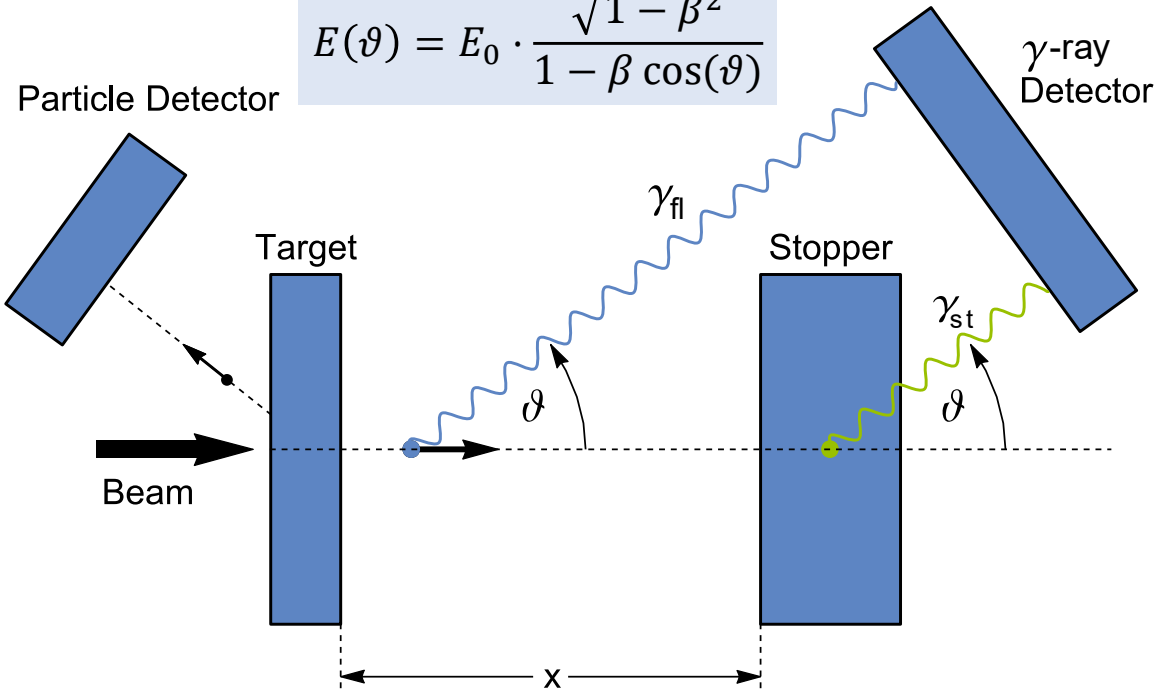


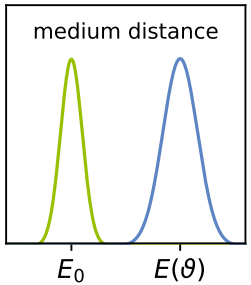
X. Huang *et al.*, NDS **133**, 221-416 (2016)

Data taken from NNDC, (1) A. Esmaylzadeh *et al.*, Phys. Rev. C **98**, 014313 (2018), (2) E. Sahin, PhD thesis, TU Darmstadt (2023)

RDDS Method

$$E(\vartheta) = E_0 \cdot \frac{\sqrt{1-\beta^2}}{1-\beta\cos(\vartheta)}$$





A. Dewald, O. Möller and P. Petkov, Prog. Part. Nucl. Phys. **67** (2012)

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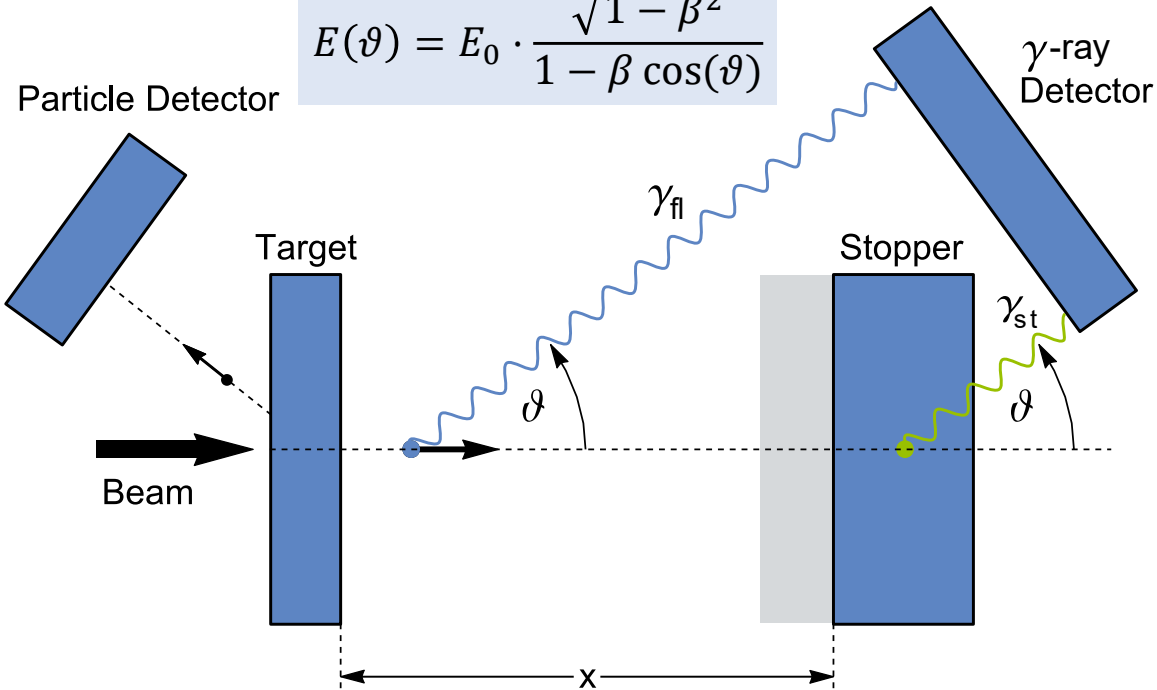

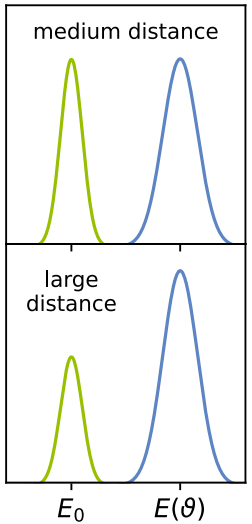

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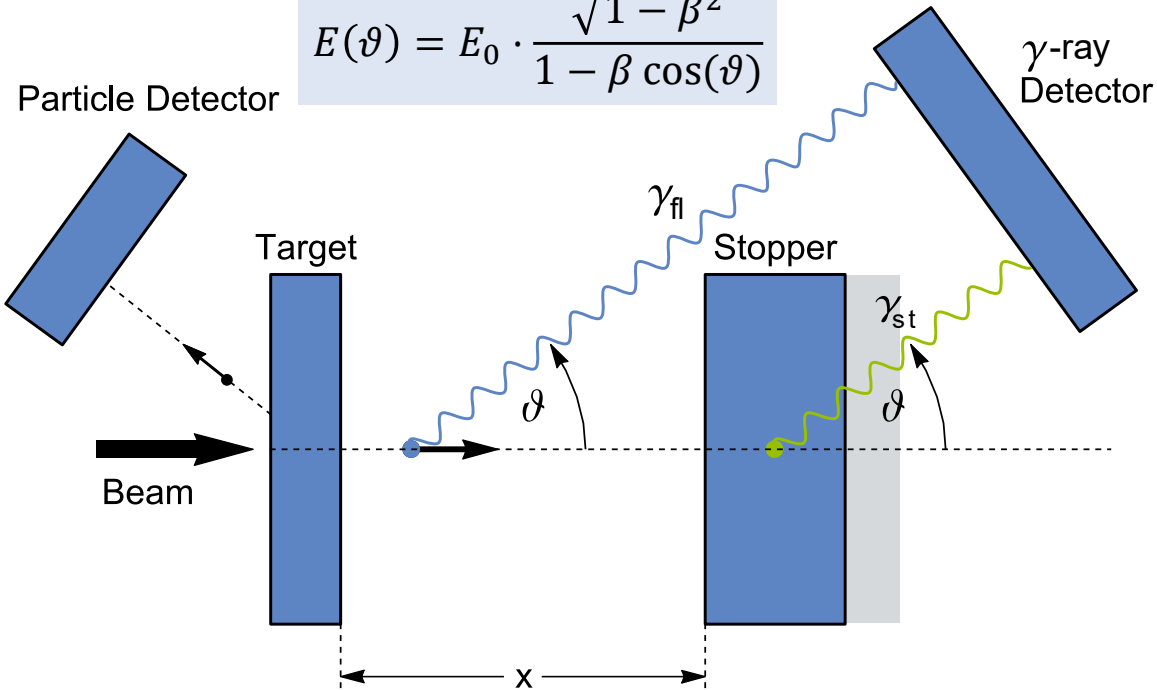
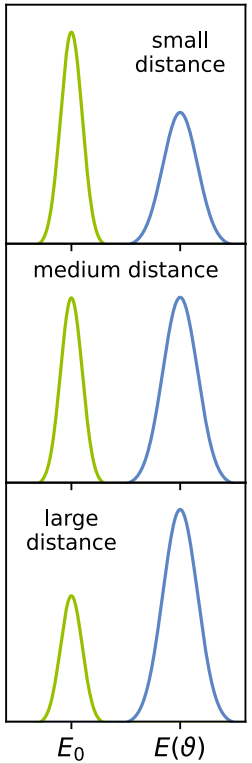




A. Dewald, O. Möller and P. Petkov, Prog. Part. Nucl. Phys. **67** (2012)

RDDS Method

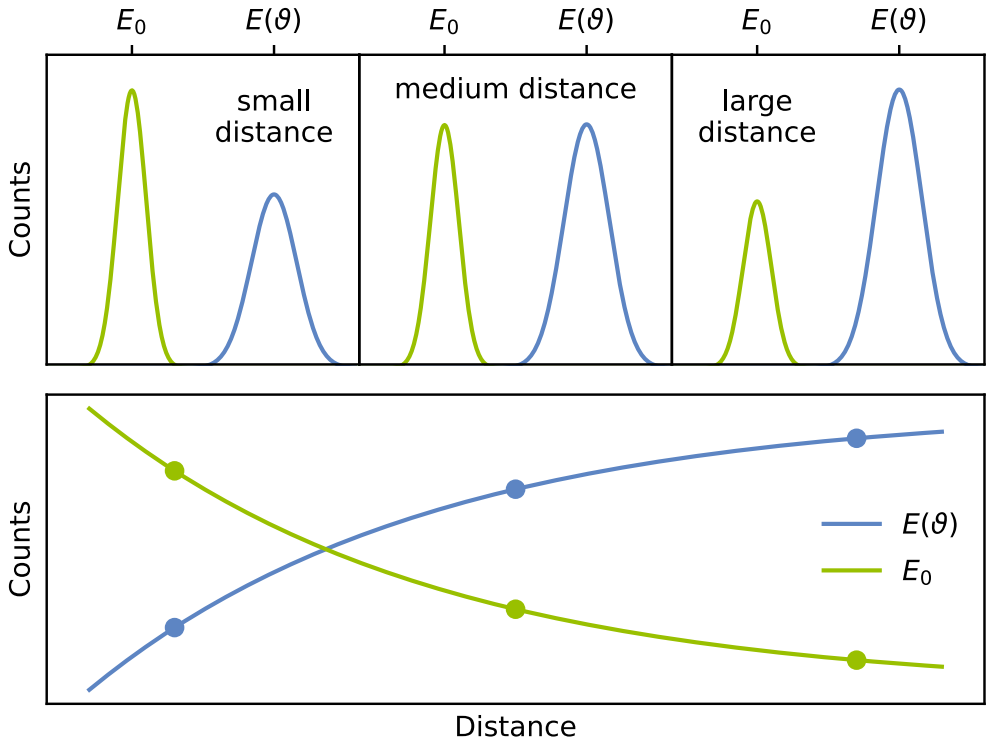
- stop component peak area

  $\sim \exp\left(\frac{-x}{\beta c \tau}\right)$

- flight component peak area

  $\sim 1 - \exp\left(\frac{-x}{\beta c \tau}\right)$

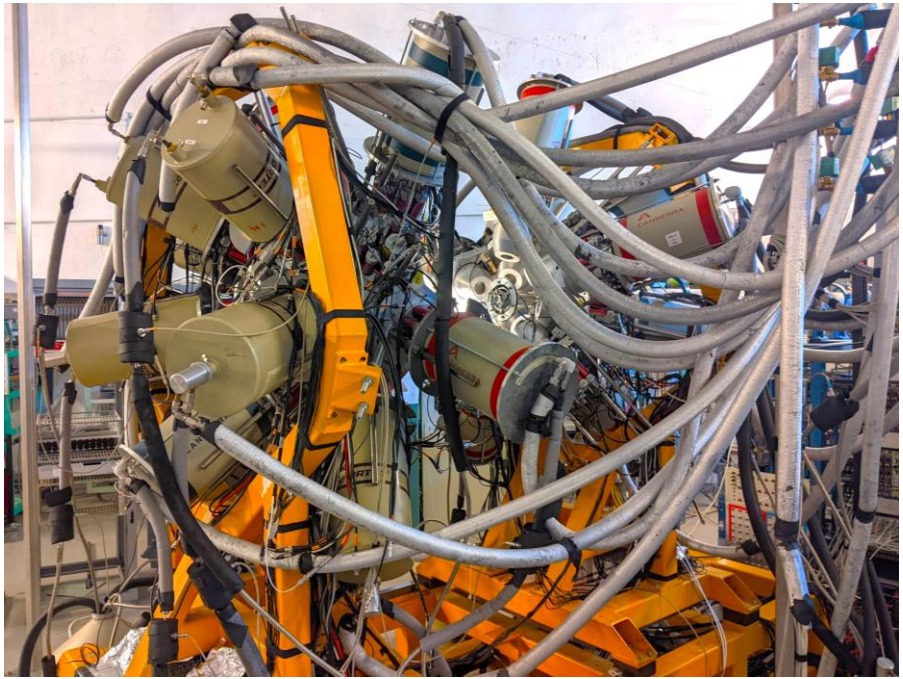
- lifetime from exponential decay behaviour



Plunger Experiment

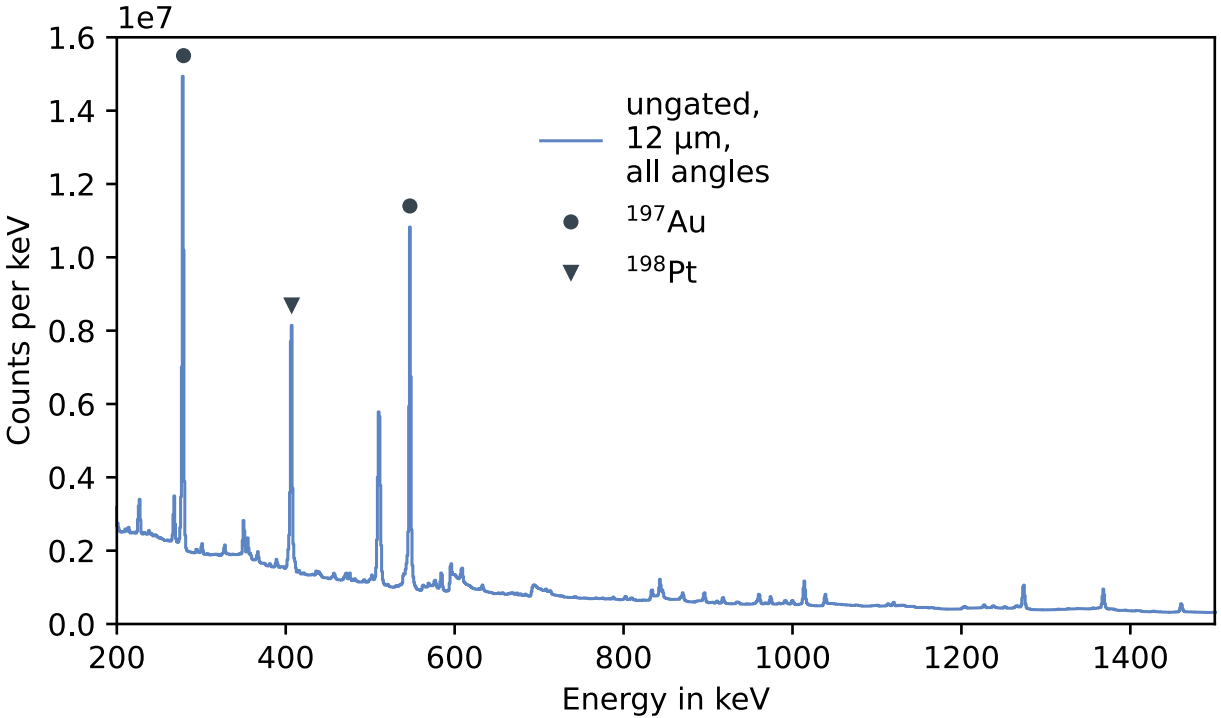
TECHNISCHE UNIVERSITÄT DARMSTADT

- 9 MV tandem accelerator with plunger setup at IFIN-HH at Bucharest-Măgurele
- ^{198}Pt(^{18}O,^{16}O)^{200}Pt at 75 MeV
- self-supporting 600 µg/cm^2 ^{198}Pt target
- ^{197}Au stopper
- 6 target-stopper distances, 12 µm to 150 µm
- ROSPHERE array with 25 HPGe detectors at 37°, 70°, 90°, 110° and 143°
- SORCERER particle detector



D. Bucurescu *et al.,* Nucl. Instrum. Meth. A **837,** 1–10 (2016)
T. Beck *et al.,* Nucl. Instrum. Meth. A **951,** 163090 (2020)

Analysis


1e7
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Counts per keV
200
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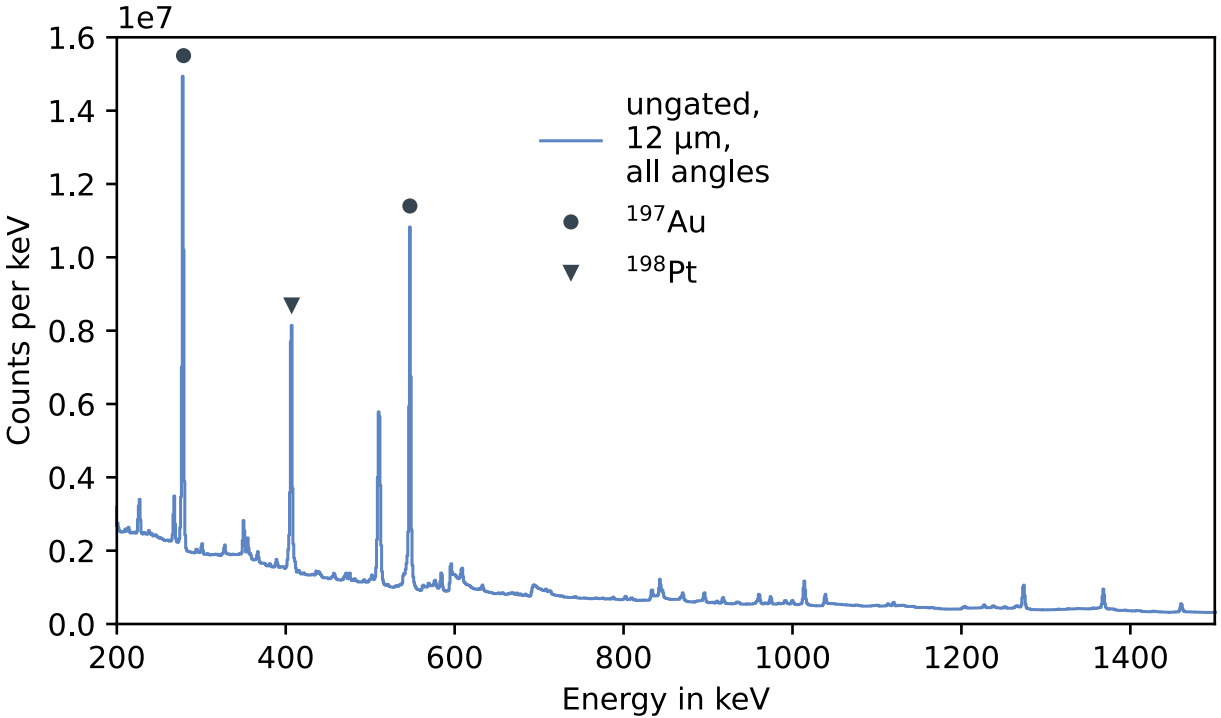
600
800
1000
1200
1400
Energy in keV
ungated,
12 µm,
all angles
^{197}Au
^{198}Pt

Analysis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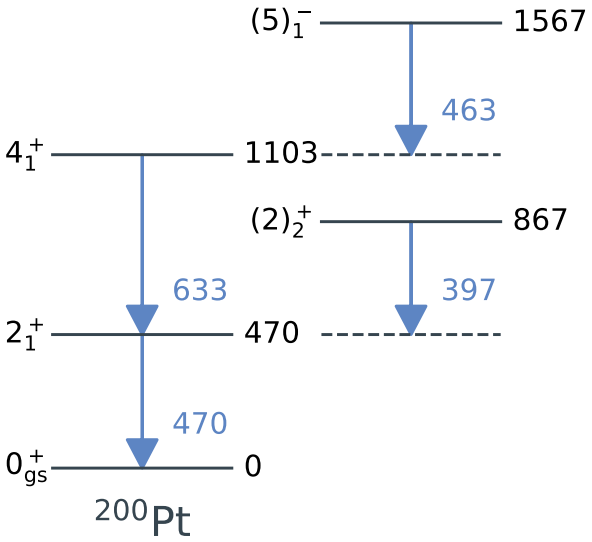
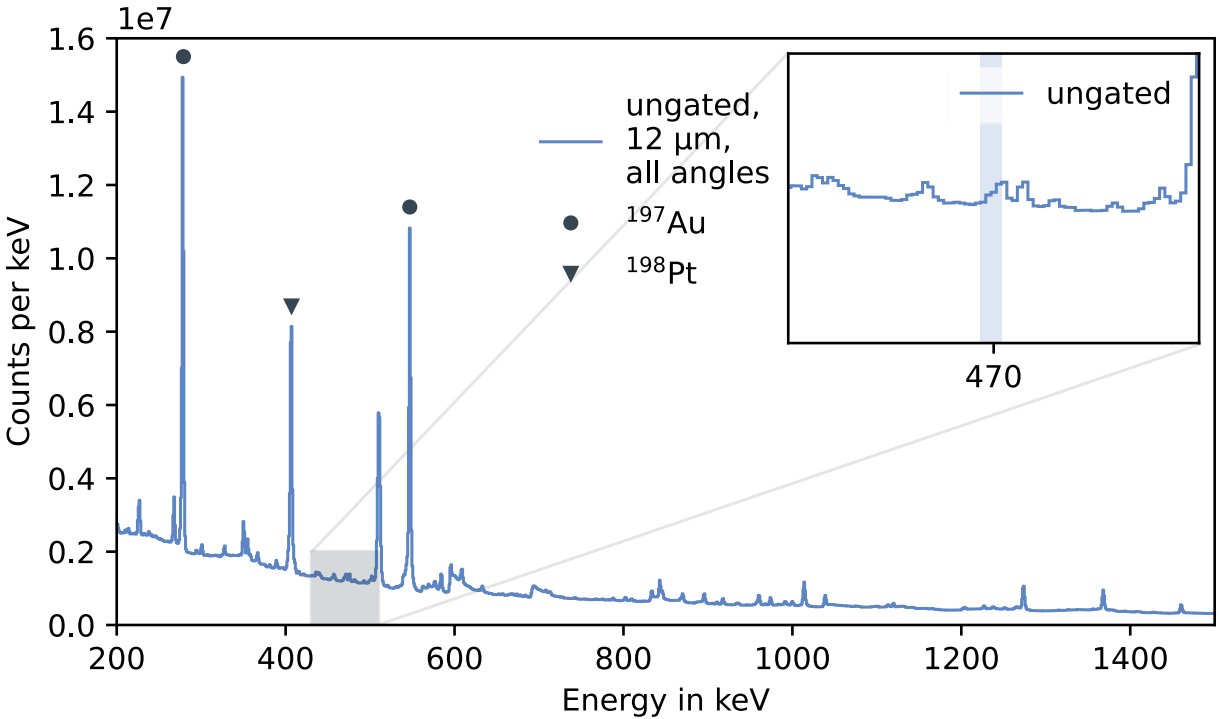

$(5)_1^-$
1567
463
4_1^+
1103
$(2)_2^+$
867
633
397
2_1^+
470
470
0_{gs}^+
0
^{200}Pt

Analysis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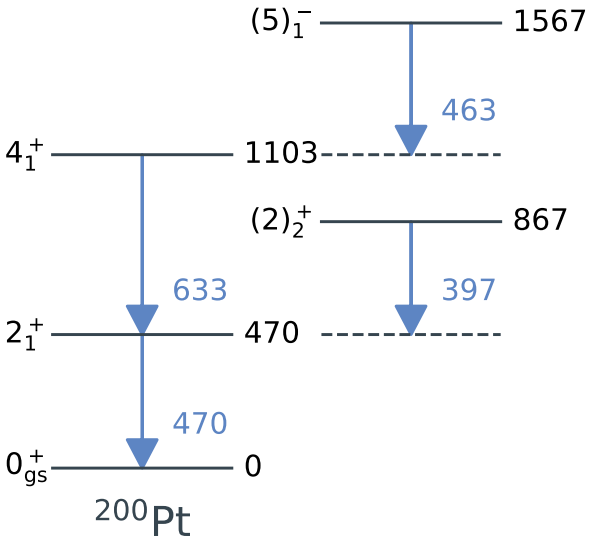
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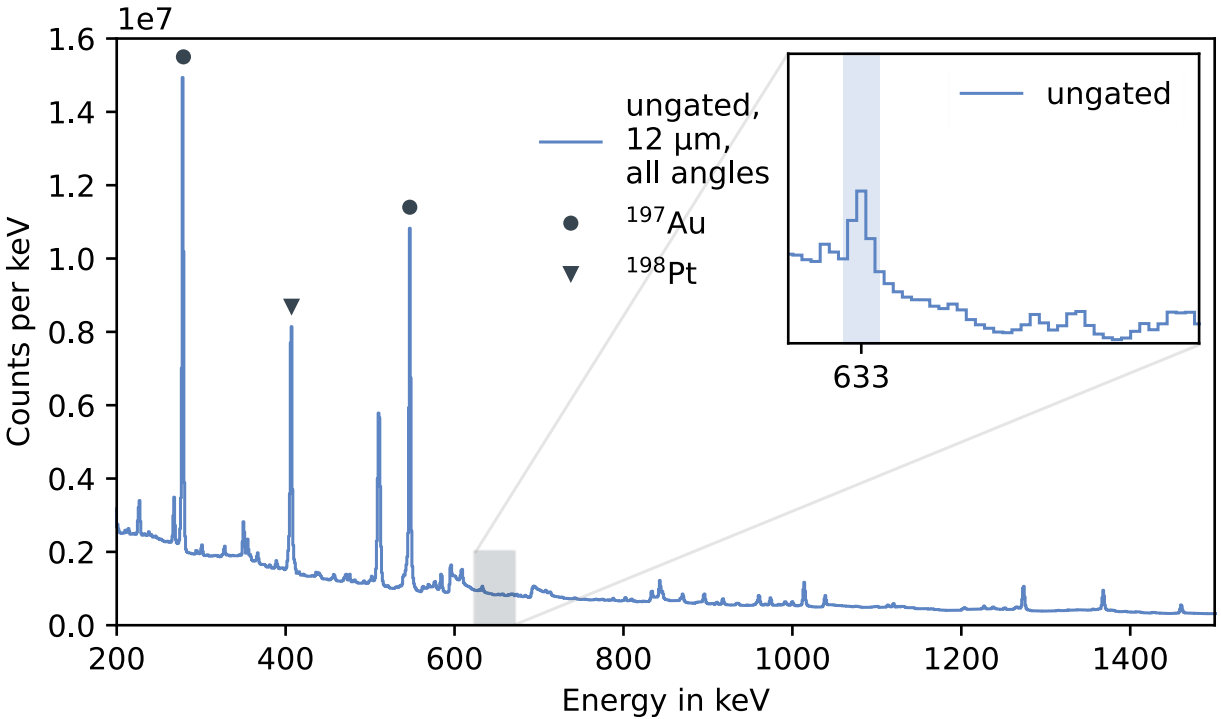
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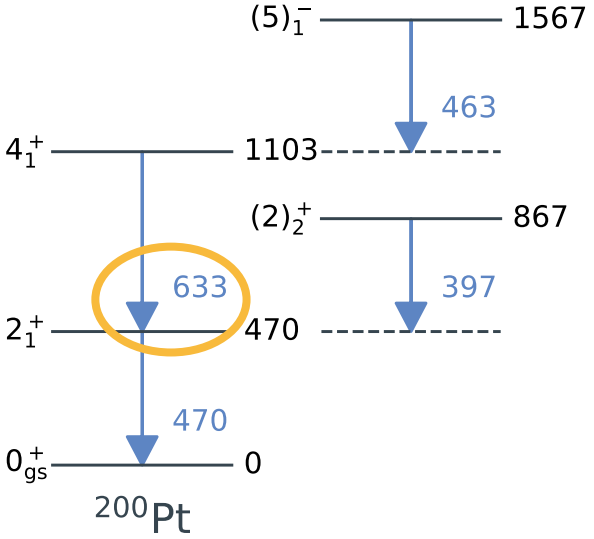
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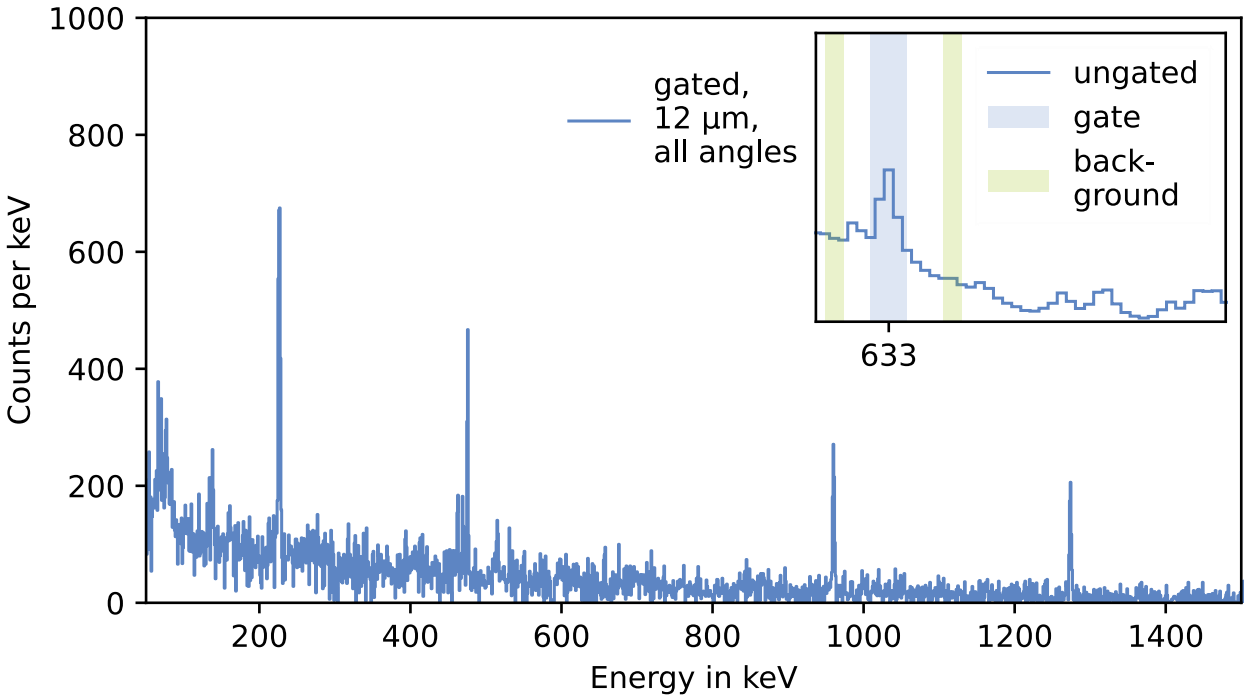
gated,
12 µm,
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633
Counts per keV
Energy in keV
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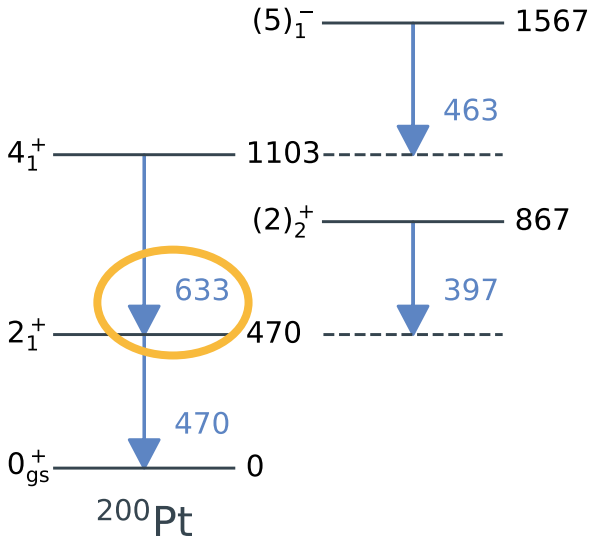
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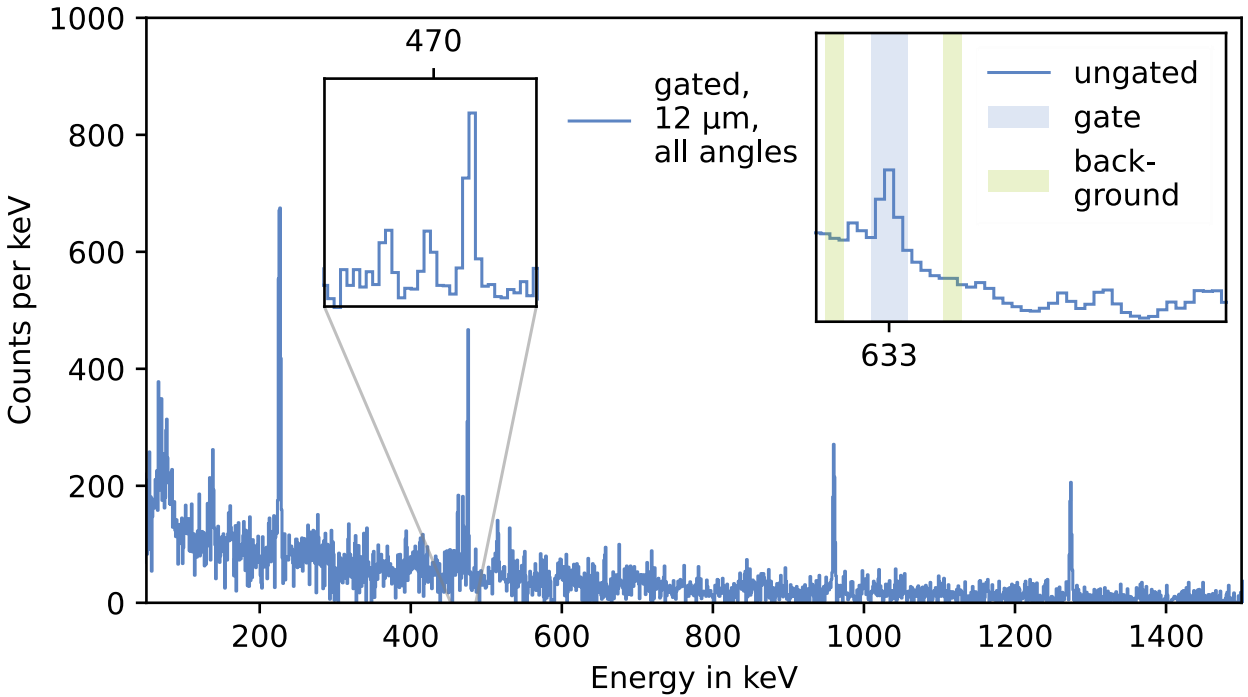
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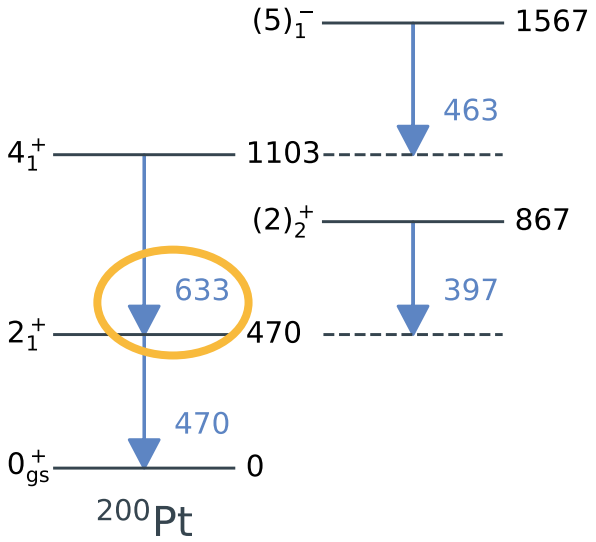
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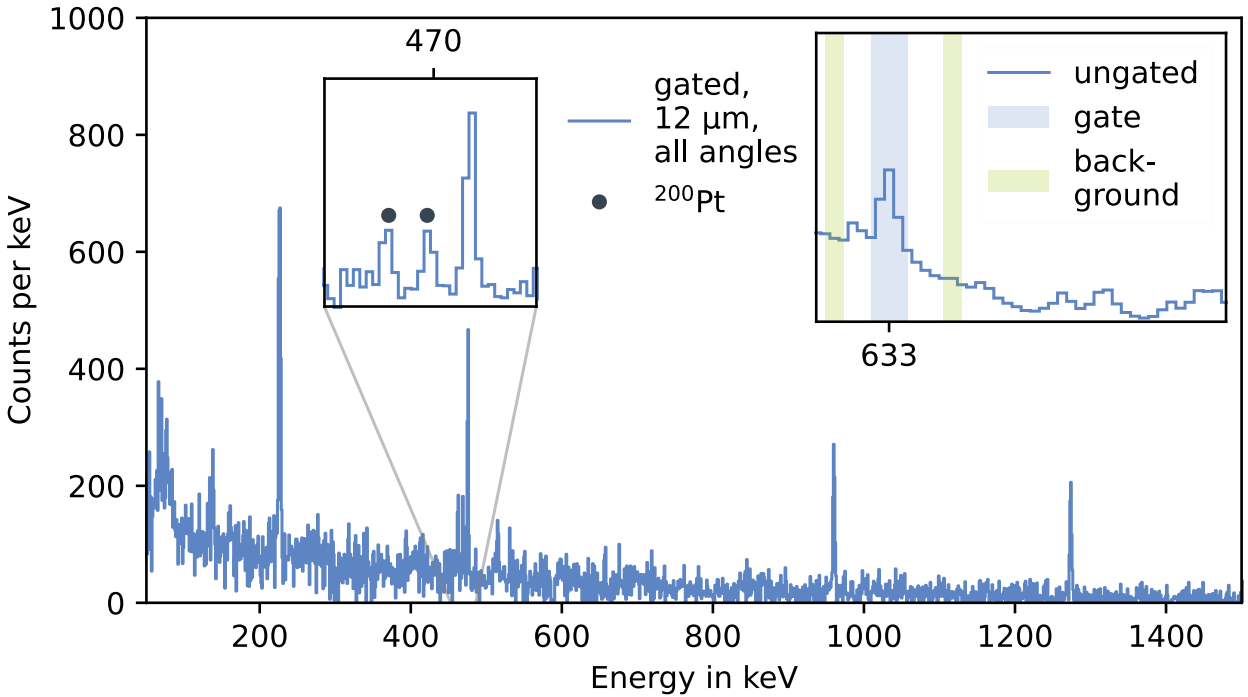
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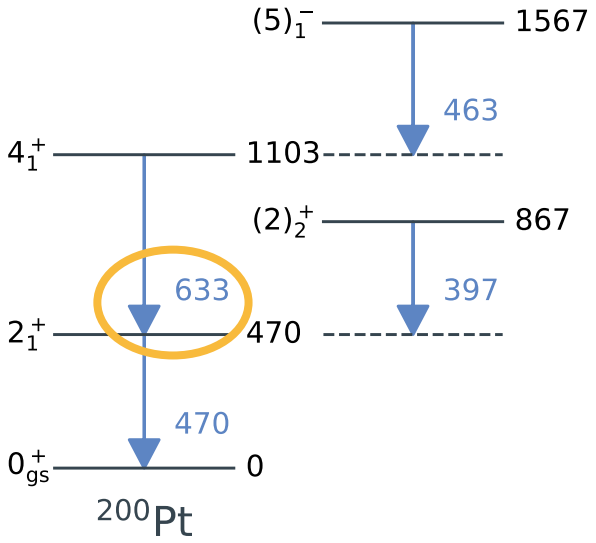
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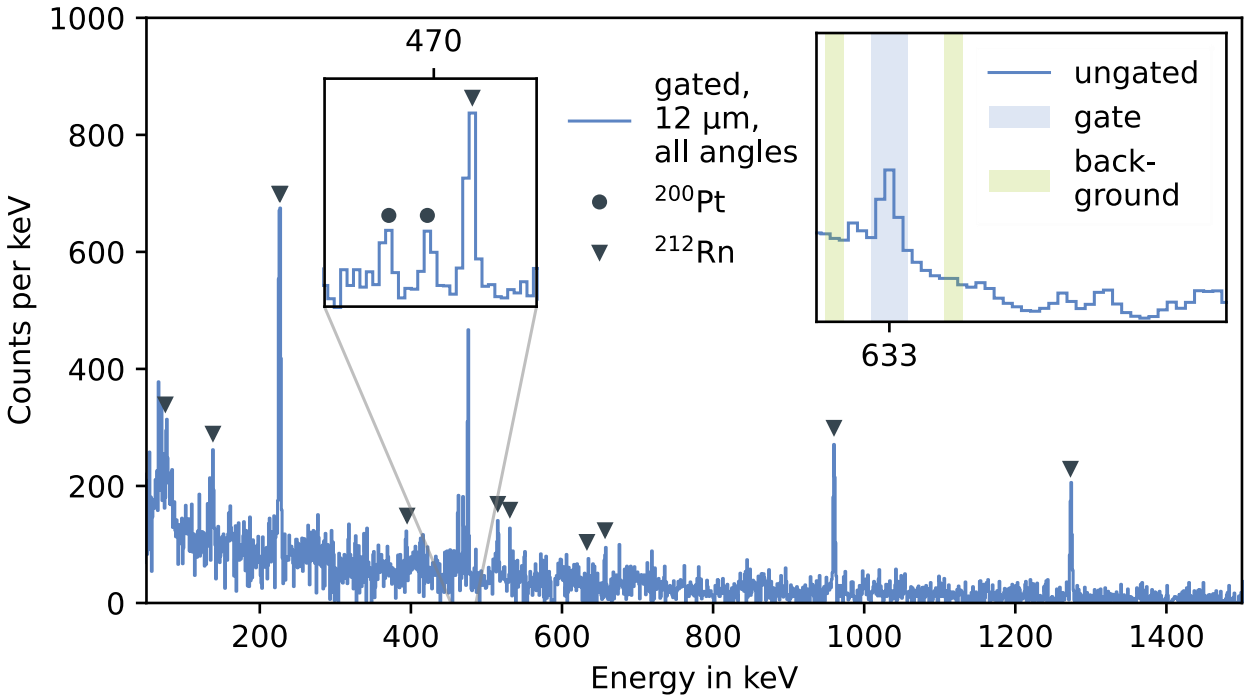
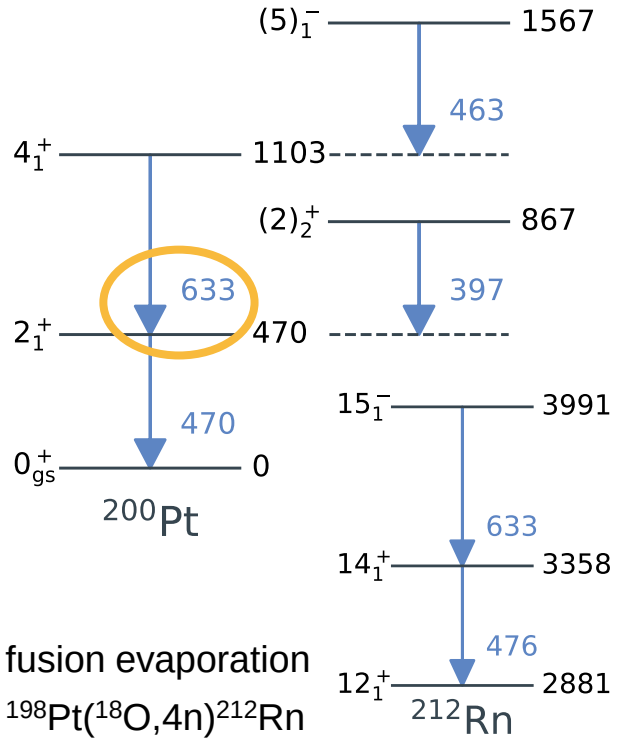
^{200}Pt

Analysis ^{212}Rn Contamination



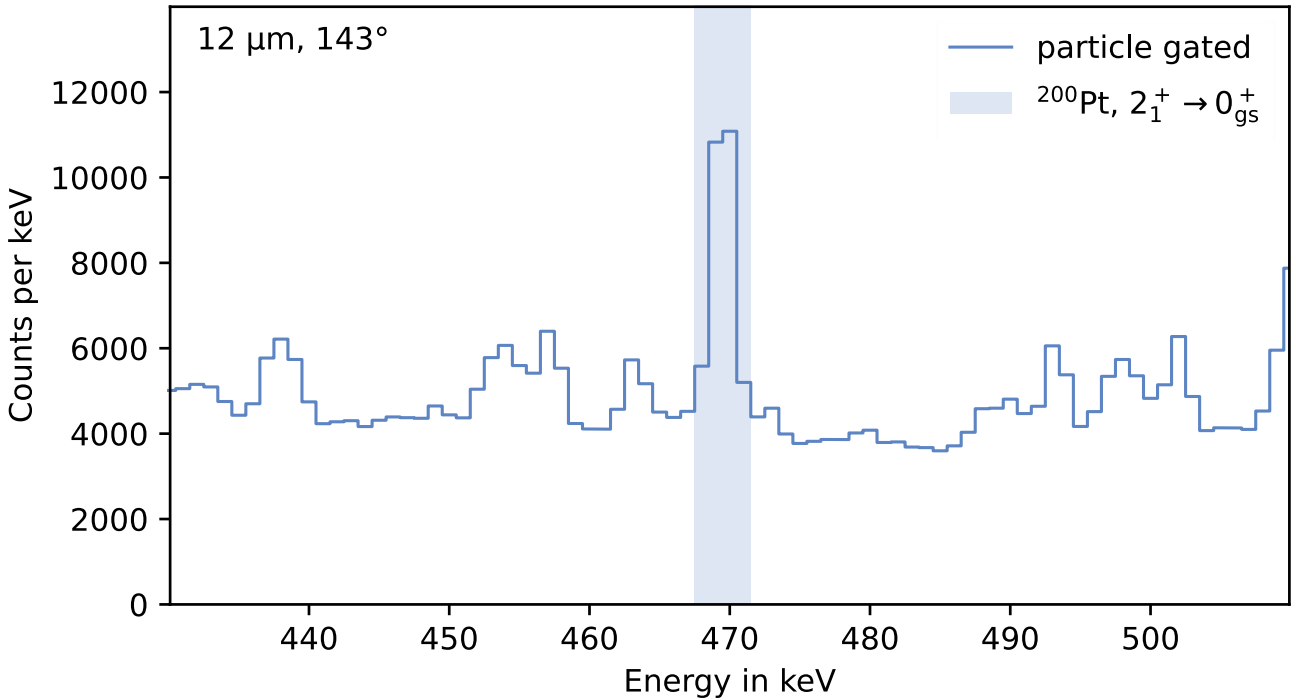


fusion evaporation
^{198}Pt(^{18}O,4n)^{212}Rn

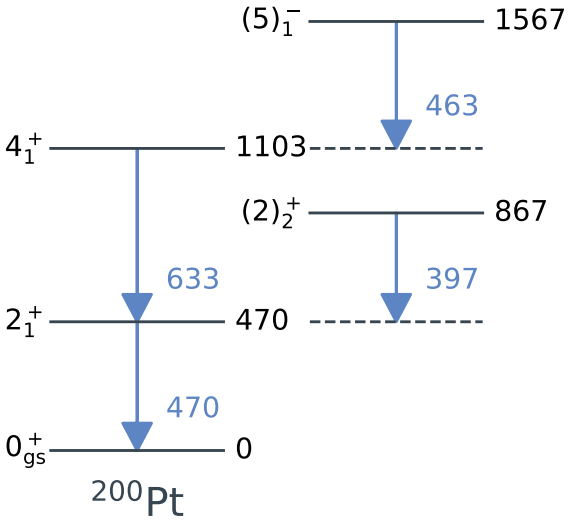
Analysis

Background Subtraction

- ^{212}Rn events excluded by time-difference gate
- only particle gated γ-singles spectra considered → feeding



Analysis Feeding



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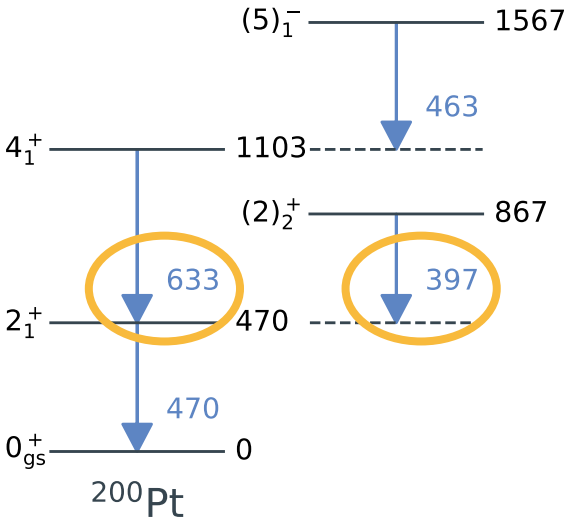
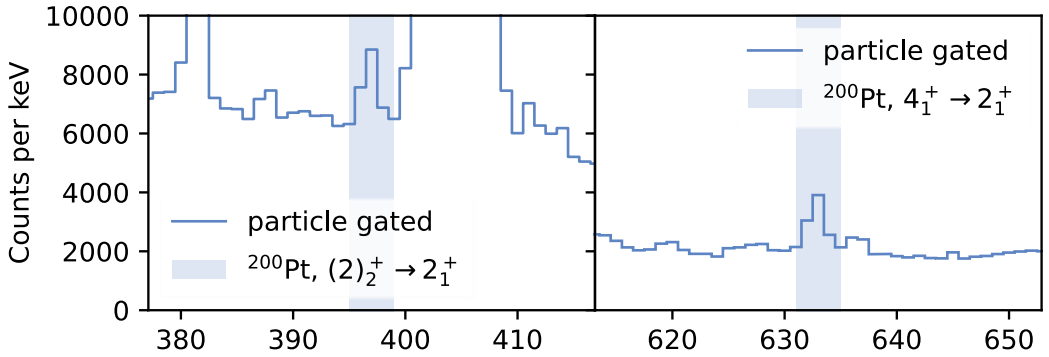
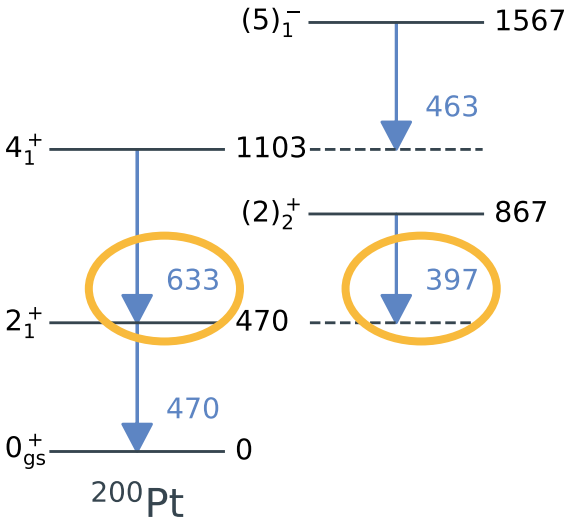
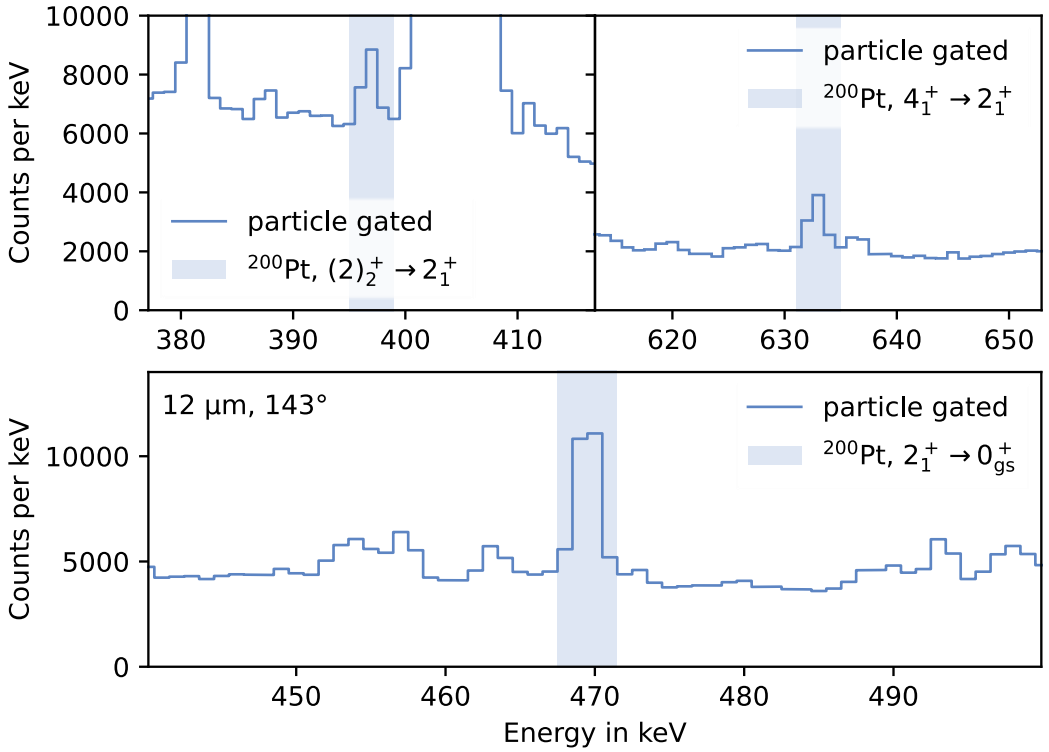




Analysis Feeding

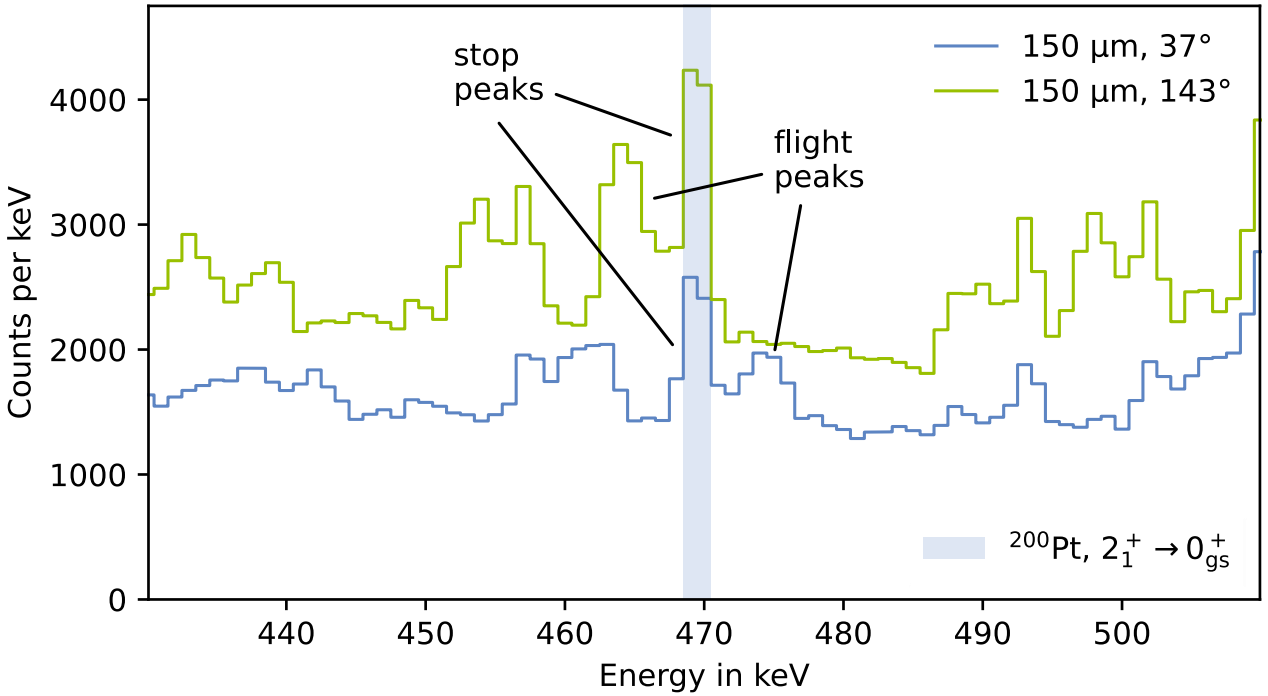


- subtract feeding stop components from 2_1^+ stop component



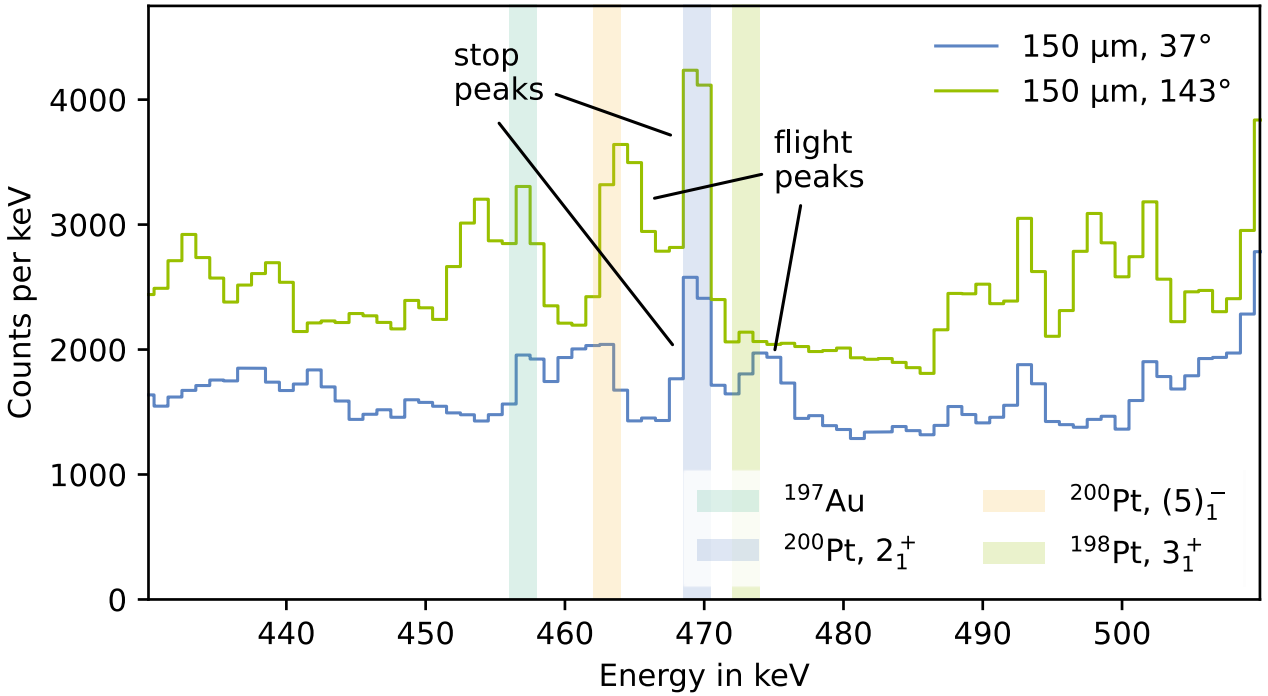
Analysis ^{197}Au, ^{198,200}Pt Contaminants at 37°, 143°

- flight components of the 2_1^+ of ^{200}Pt overlapping with other transitions at 37° and 143°



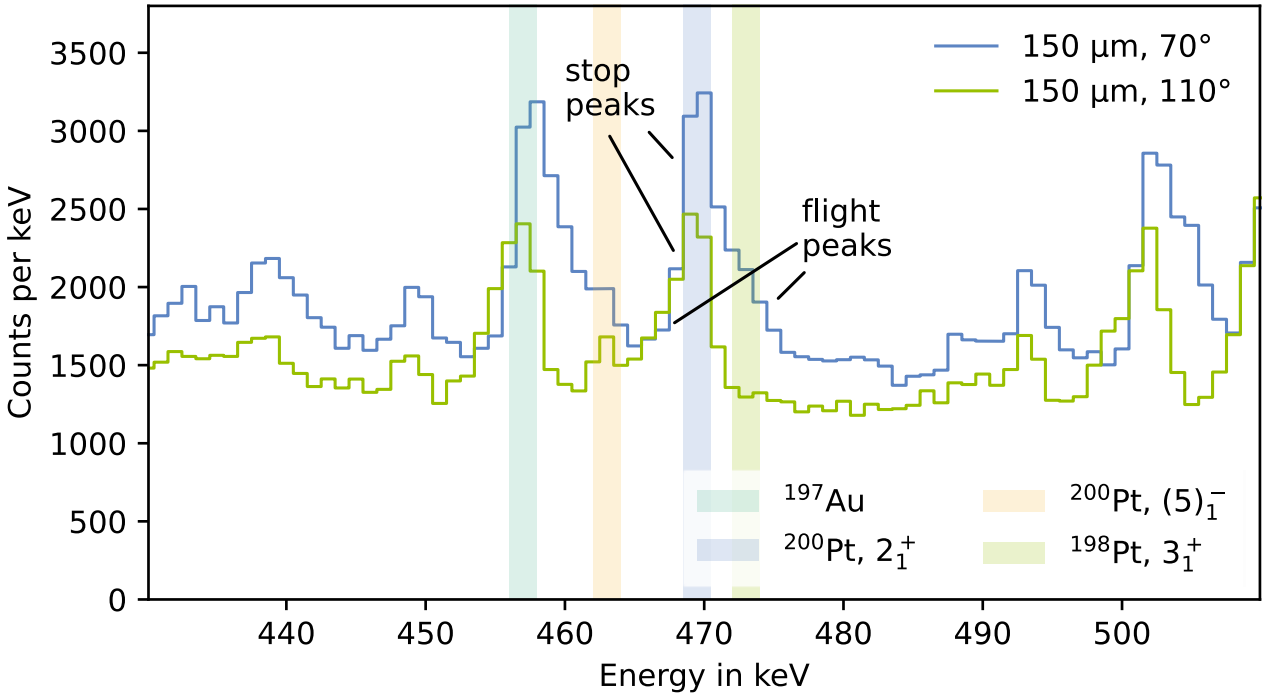
Analysis ^{197}Au, ^{198,200}Pt Contaminants at 37°, 143°

- flight components of the 2_1^+ of ^{200}Pt overlapping with other transitions at 37° and 143°
- corrections necessary to isolate the flight components



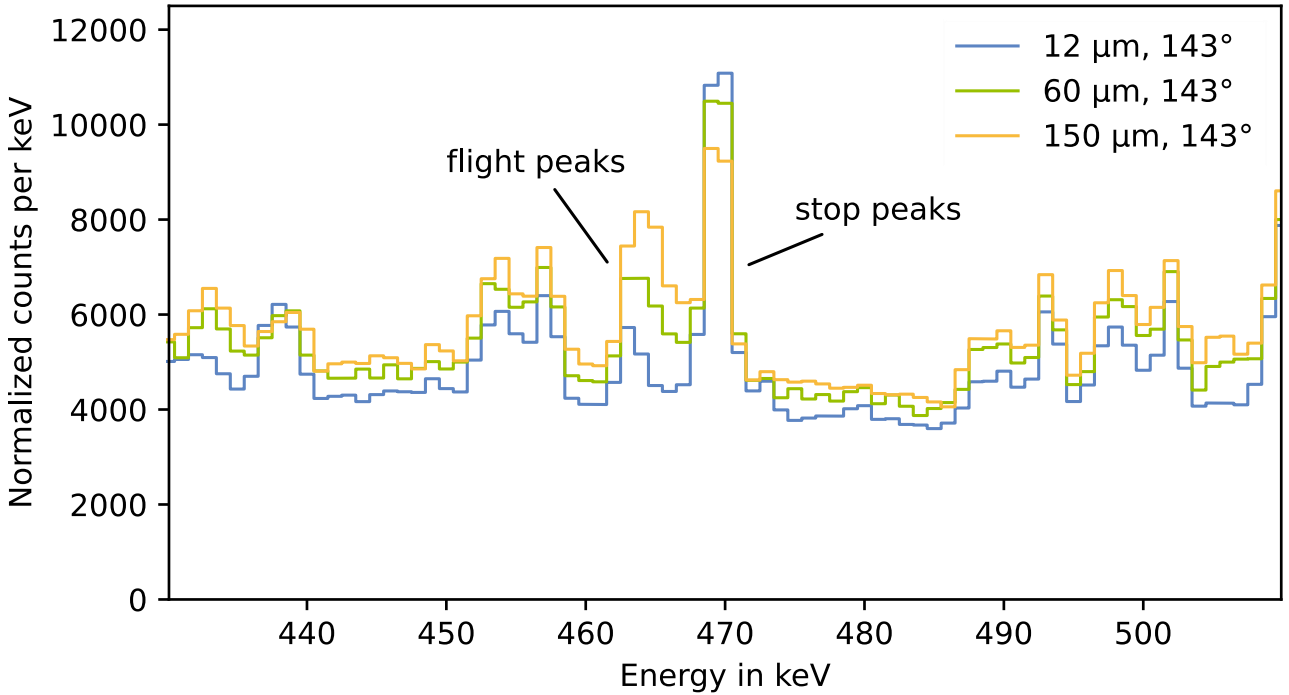
Analysis ^{197}Au, ^{198,200}Pt Contaminants at 70°, 110°

- only minor correction applied to the 2_1^+ flight component at 70° and 110°



Analysis Lifetime determination

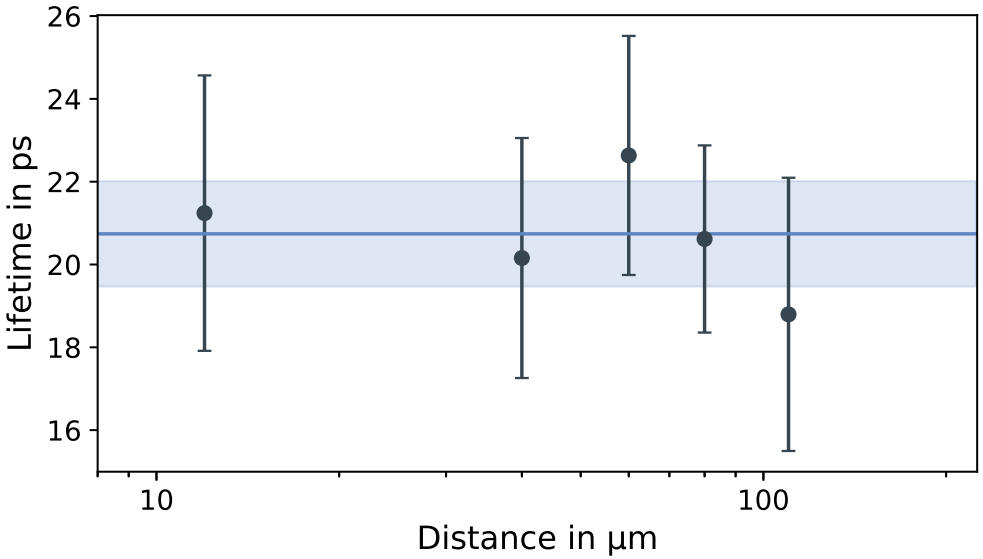
- Differential Decay Curve Method using napatau
- $\tau_i = \frac{I_i^{\mathrm{st}}}{\frac{\mathrm{d}}{\mathrm{d}t} I_i^{\mathrm{fl}}} = \frac{I_i^{\mathrm{st}}}{v \frac{\mathrm{d}}{\mathrm{d}x} I_i^{\mathrm{fl}}}$
- mean lifetime follows from χ^2 fit

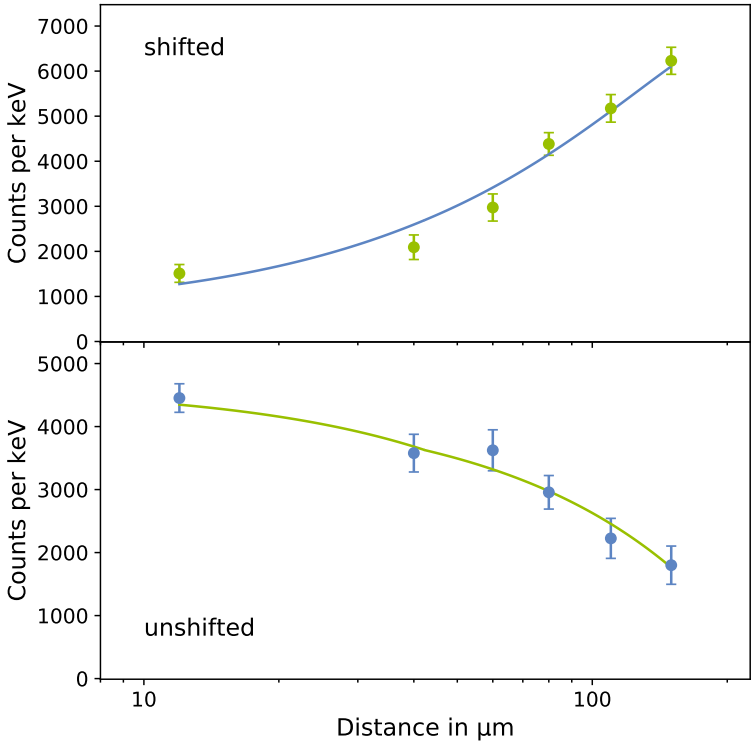


B. Saha, PhD thesis, U Cologne (2004)

Analysis napatau – 70°

- $\tau_{\mathrm{fw}} = 20.7\ ^{+2.0}_{-1.9}$ ps

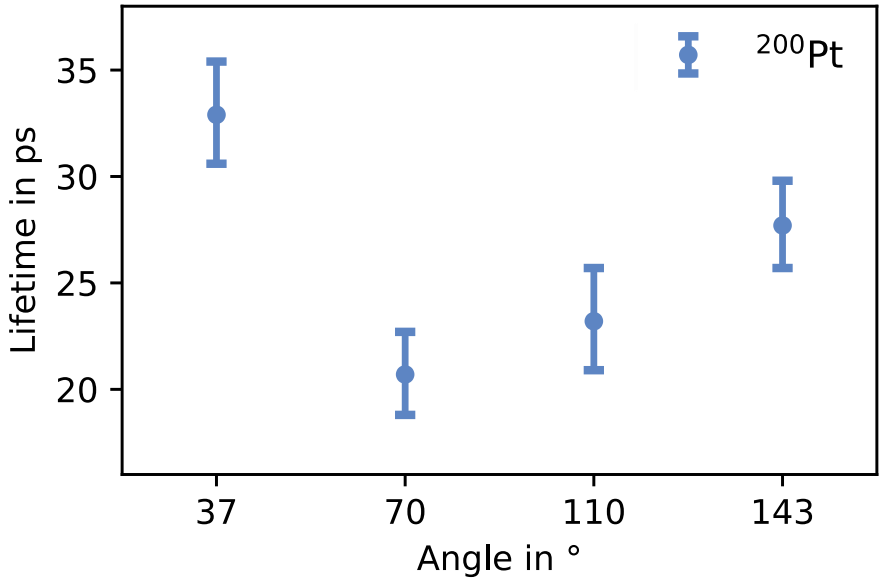




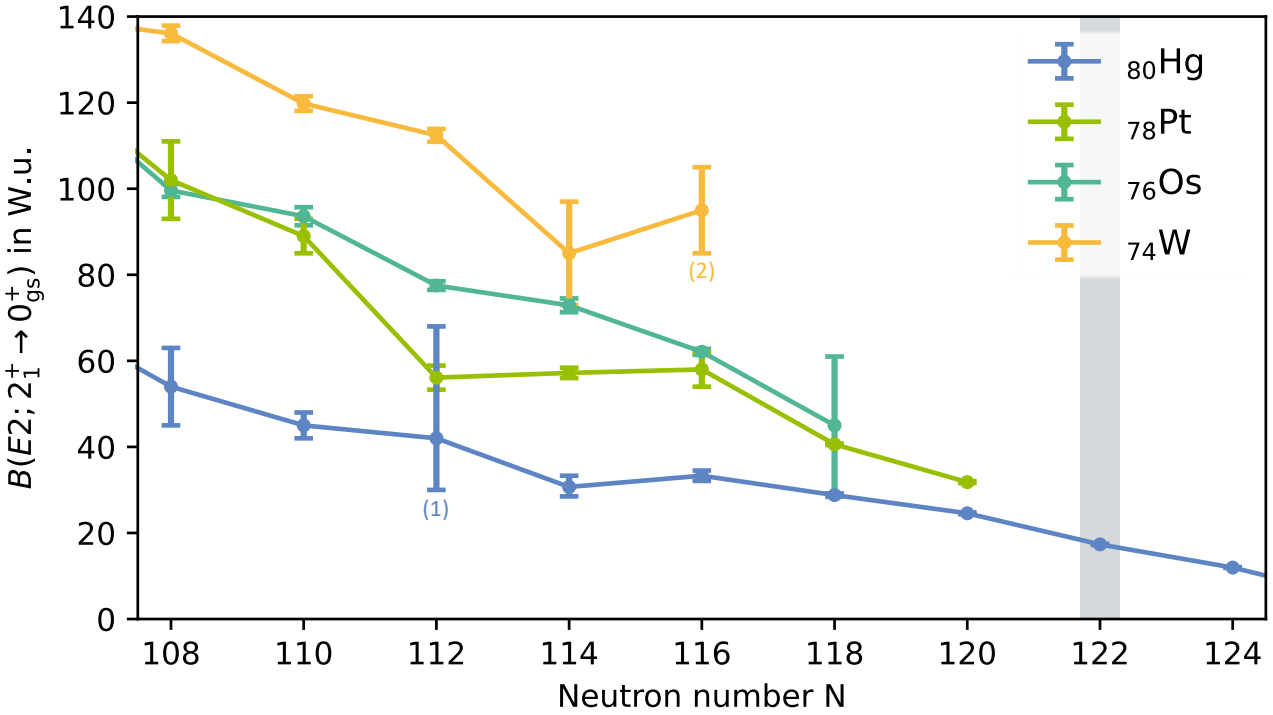
Results

- napatau fits performed for all detector angles

	τ in ps
37°	$32.9\ ^{+2.5}_{-2.3}$
70°	$20.7\ ^{+2.0}_{-1.9}$
110°	$23.2\ ^{+2.5}_{-2.3}$
143°	$27.7\ ^{+2.1}_{-2.0}$



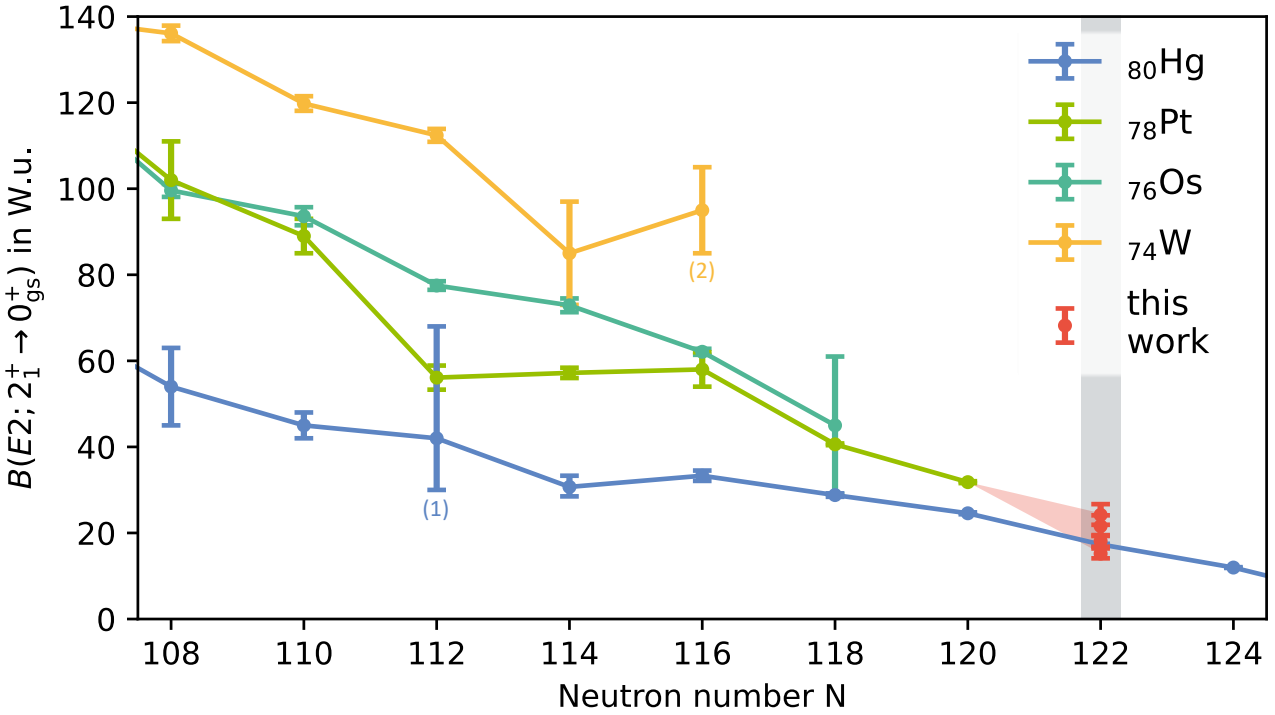
Results



Data taken from NNDC, (1) A. Esmaylzadeh *et al.*, Phys. Rev. C **98**, 014313 (2018), (2) E. Sahin, PhD thesis, TU Darmstadt (2023)

Results

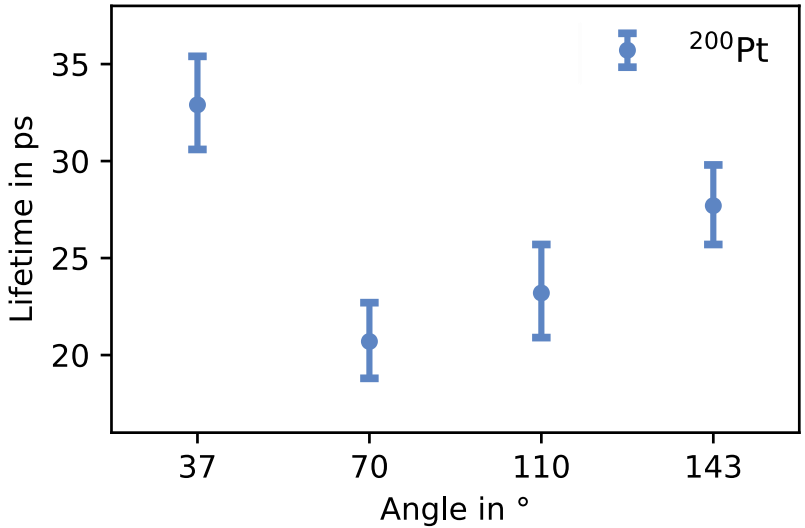
	τ in ps	B(E2) in W.u.
37°	$32.9\,^{+2.5}_{-2.3}$	$15.2\,^{+1.2}_{-1.1}$
70°	$20.7\,^{+2.0}_{-1.9}$	$24.2\,^{+2.5}_{-2.3}$
110°	$23.2\,^{+2.5}_{-2.3}$	$21.6\,^{+2.5}_{-2.3}$
143°	$27.7\,^{+2.1}_{-2.0}$	$18.1\,^{+1.4}_{-1.3}$



Data taken from NNDC, (1) A. Esmaylzadeh *et al.*, Phys. Rev. C **98**, 014313 (2018), (2) E. Sahin, PhD thesis, TU Darmstadt (2023)

Discussion

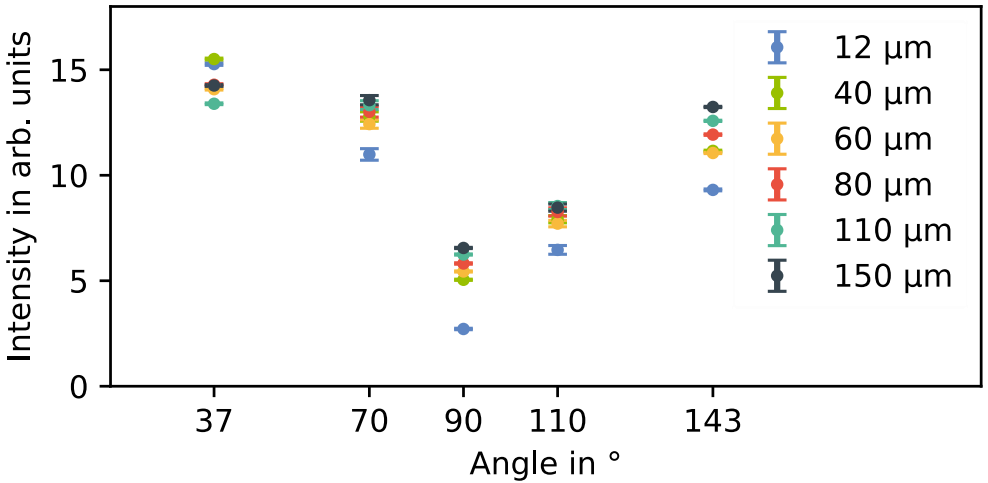
- discrepancies between angles

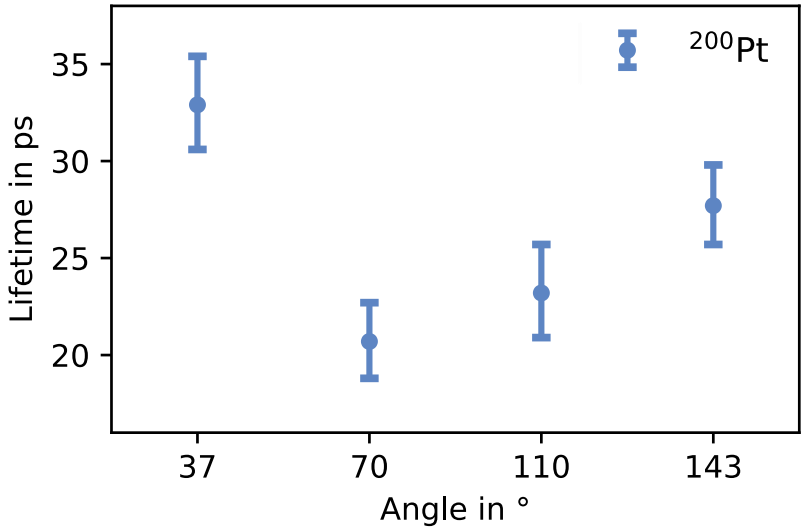


Discussion

Angular distribution

- discrepancies between angles
- angular distribution of $2_1^+ \rightarrow 0_1^+$ of ^{198}Pt

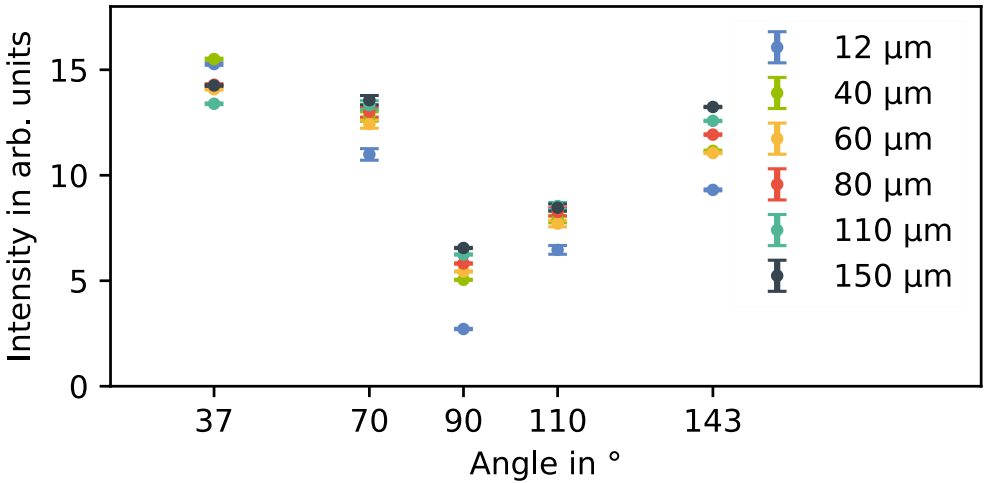


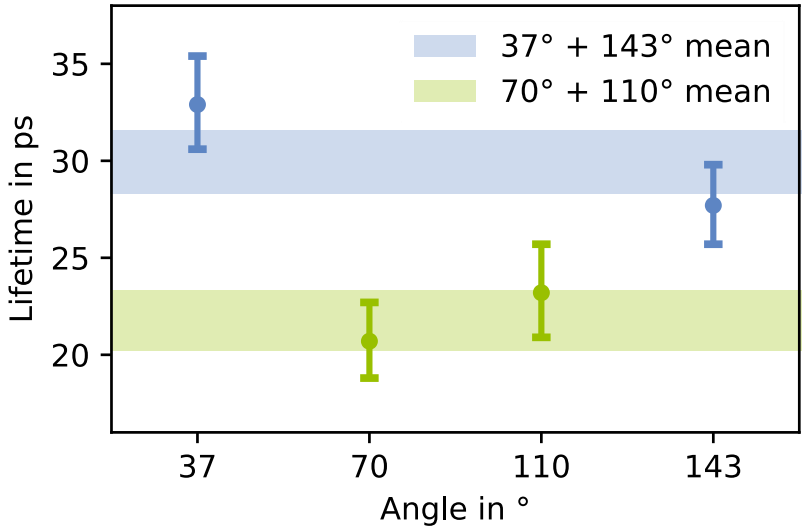


Discussion

Angular distribution

- discrepancies between angles
- angular distribution of $2_1^+ \rightarrow 0_1^+$ of ^{198}Pt



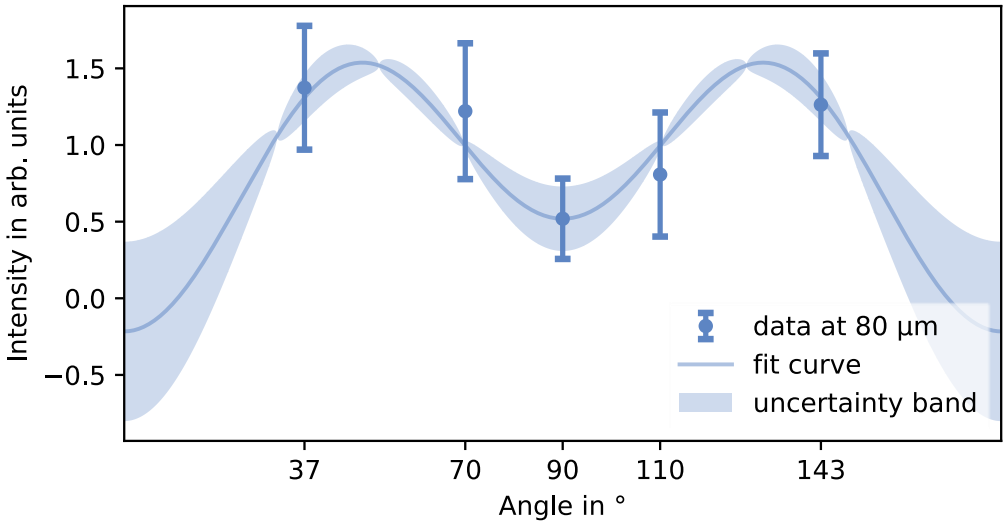


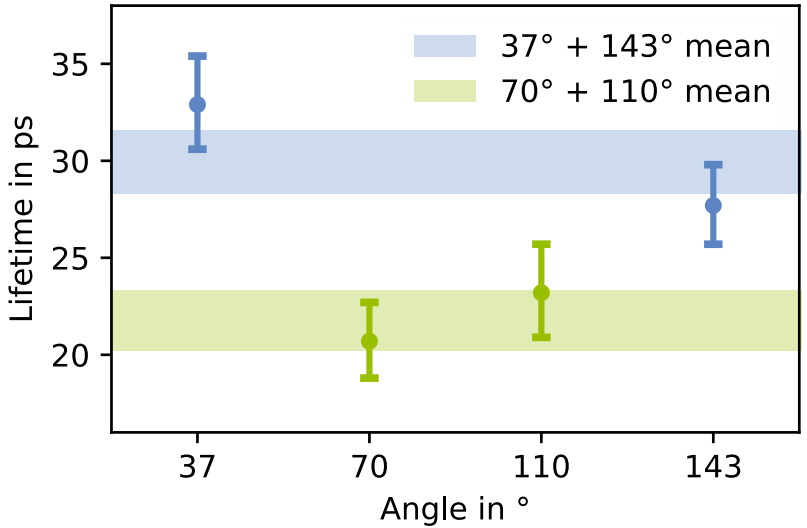
2_1^+ of ^{200}Pt affected by de-orientation?

Discussion

Angular distribution

$$W(\vartheta)/A_0' = 1 + \frac{A_2'}{A_0'} P_2(\cos\vartheta) + \frac{A_4'}{A_0'} P_4(\cos\vartheta)$$

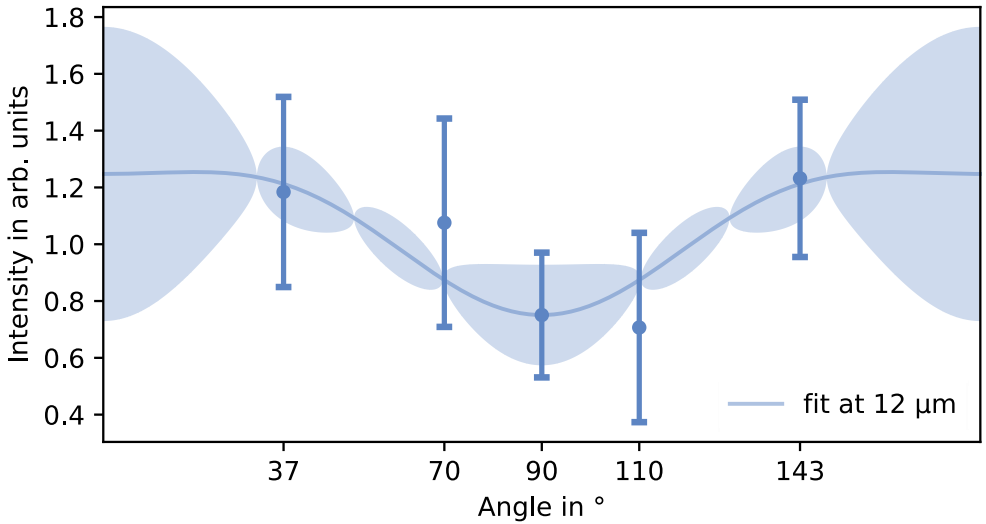




2_1^+ of ^{200}Pt affected by de-orientation?

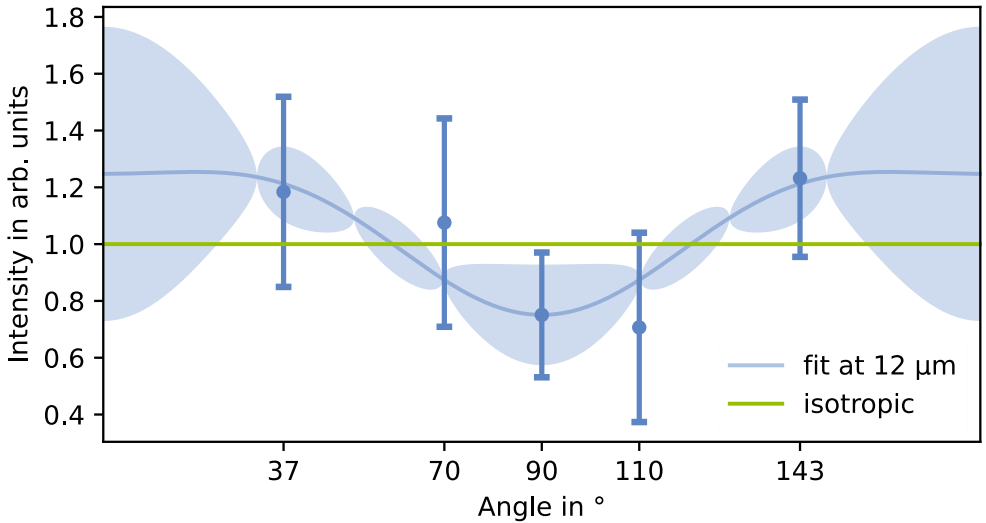
Discussion De-orientation

- estimate maximum influence



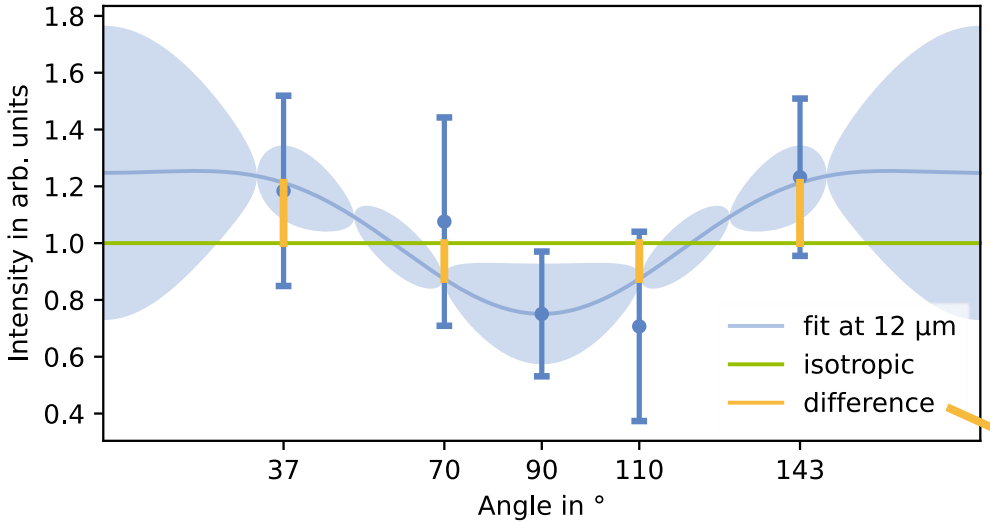
Discussion De-orientation

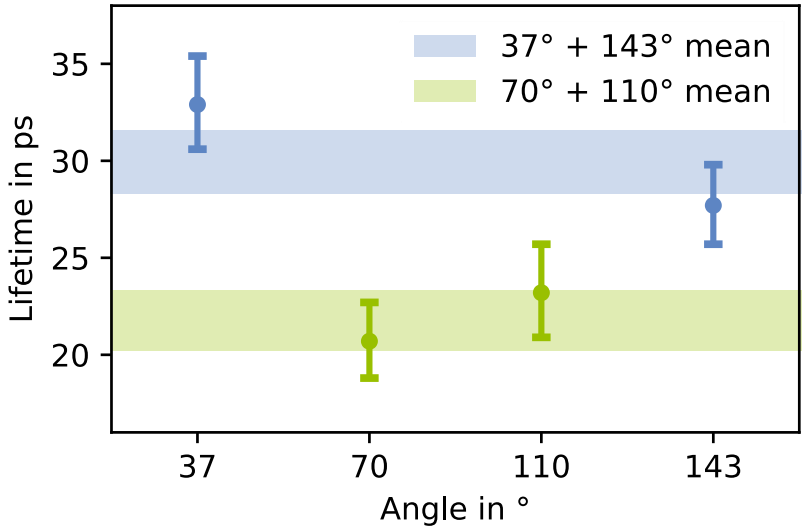
- assume isotropic angular distribution at largest distance



Discussion De-orientation

- assume isotropic angular distribution at largest distance

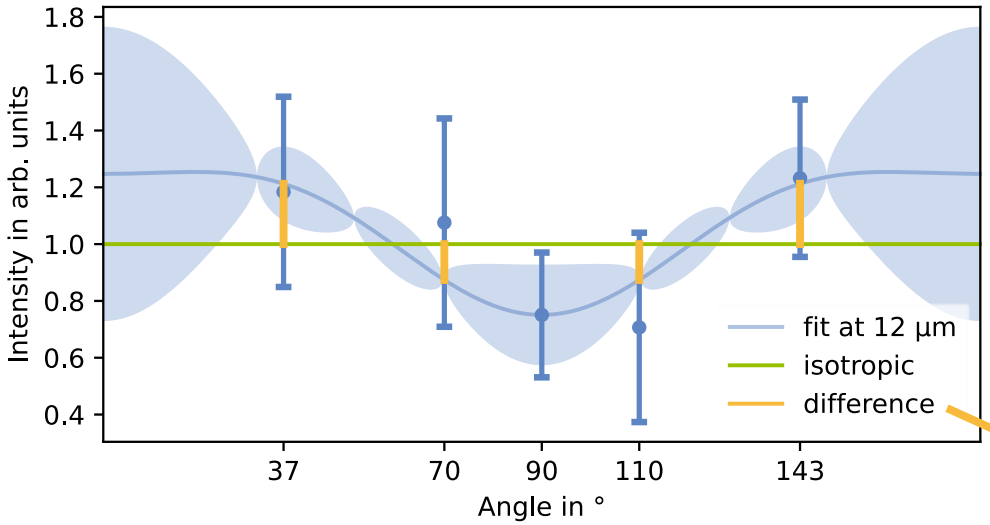


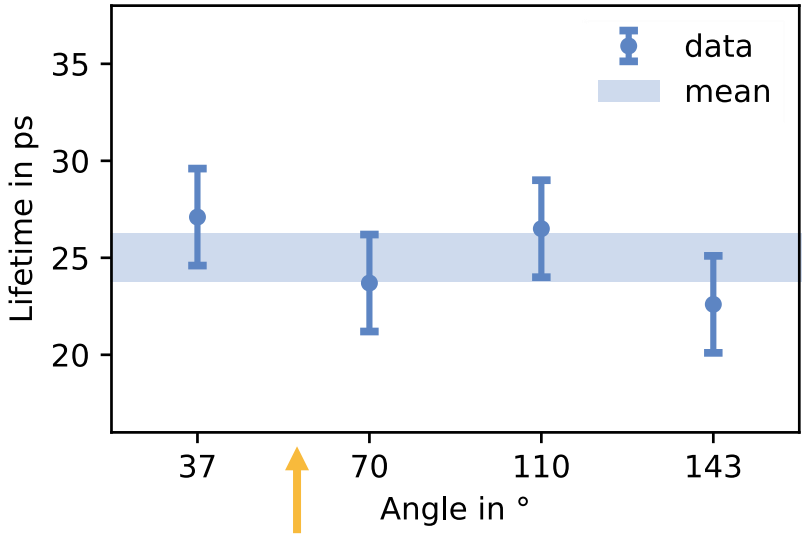


correction factors from difference between distributions

Discussion De-orientation

- correction applied to peak areas of stop components

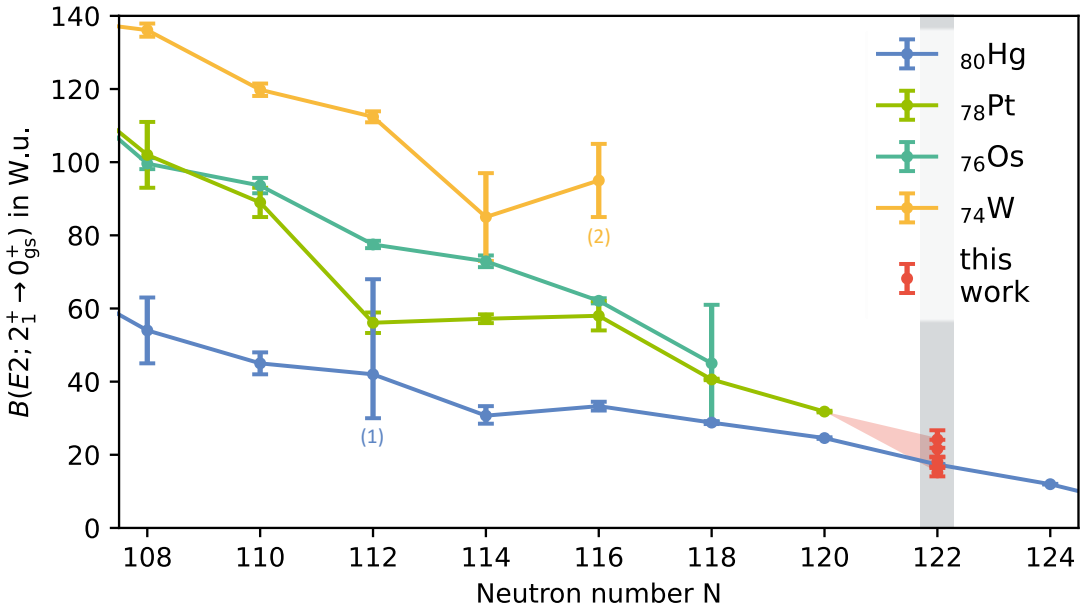




correction factors from difference between distributions

Summary and Outlook

- lifetime results of the 2_1^+ state of ^{200}Pt determined for first time
- expected declining trend of $B(E2)$ towards neutron shell closure confirmed

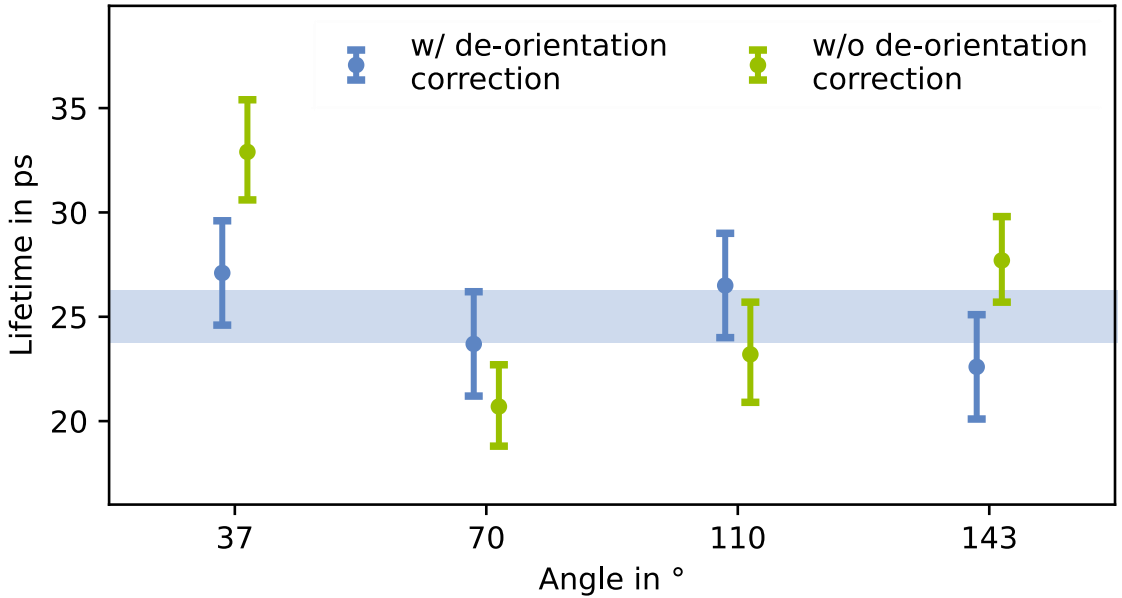


Data taken from NNDC, (1) A. Esmaylzadeh *et al.*, Phys. Rev. C **98**, 014313 (2018), (2) E. Sahin, PhD thesis, TU Darmstadt (2023)

Summary and Outlook

- lifetime results of the 2_1^+ state of ^{200}Pt determined for first time
- expected declining trend of $B(E2)$ towards neutron shell closure confirmed
- discrepancy between detector angles requires further investigation

  → de-orientation



Thank you for your attention!

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