



Lifetime measurements of low-lying states in midshell Te isotopes

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$B(E2)$ gives information on shell model parameters

"Dip" in midshell $B(E2)$ for ^{50}Sn :

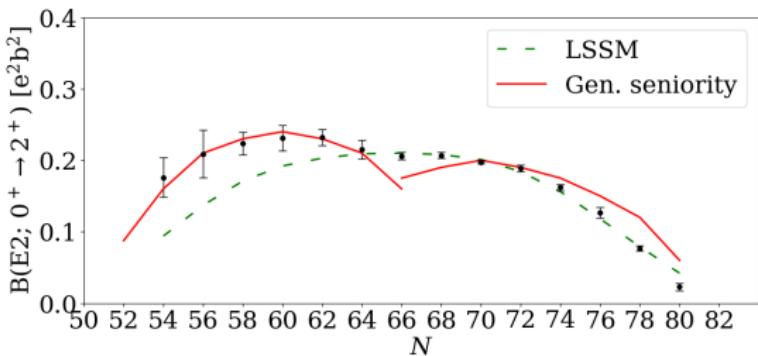


Figure 1: $B(E2; 0^+ \rightarrow 2^+)$ values for the Sn isotopic chain. Experimental data (black points), LSSM calculations¹ (dashed line), Generalized seniority² (solid line).

Is this also present in the ^{50}Te curve?

¹Bäck, T. et al. (2013) *Phys. Rev. C*, 87(3): 1–4

²Maheshwari, B. et al (2016) *Nucl. Phys. A*, 952, 62–69

Uncertainty at N=66 too large to decide shape in midshell

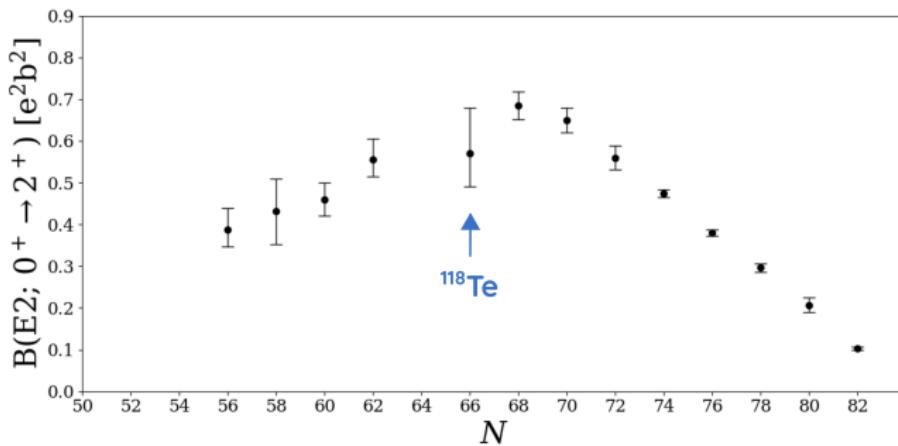


Figure 2: $B(E2; 0^+ \rightarrow 2^+)$ values for the Te isotopic chain. Values taken from the evaluator nndc.bnl.gov/be2/ and ^{110}Te from Testov et al., Physical Review C, 103(4):1–12, 2021.

Aim: Remeasure and hopefully reduce uncertainty

Aim: Measure lifetime of yrast 2^+ state in ^{118}Te

$$B(E2 \uparrow) = \frac{40.81 \times 10^{13}}{E^5 \times \tau \times (1+\alpha)}$$

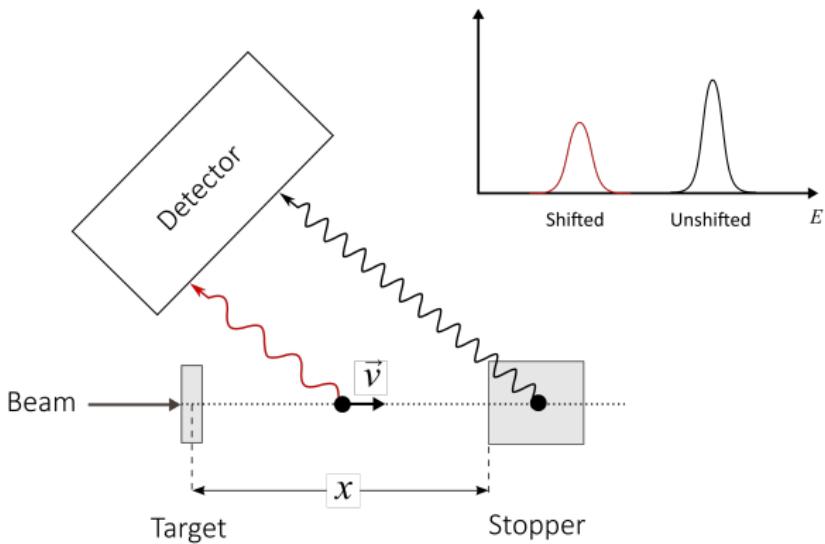


Figure 3: Recoil Distance Doppler-shift measurement

Setup at JYFL accelerator laboratory

- ▶ Jurogam II + DPUNS plunger
- ▶ $^{100}\text{Mo}(^{22}\text{Ne}, 4n)^{118}\text{Te}$
- ▶ Beam energy: 75 MeV
- ▶ Thick Au stopper foil

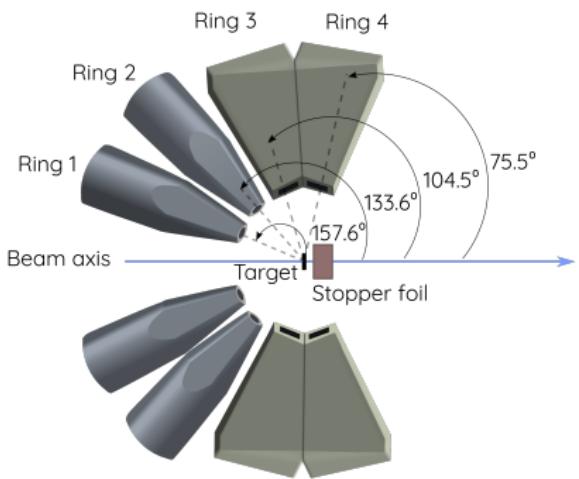


Figure 4: Schematic figure of the setup.
Figure not to scale.

Vibrational-like structure of ^{118}Te makes fitting difficult

- ▶ Previous measurement:
 - ▶ Pasternak et al. (2002)^a :
 $\tau = 8.8 \pm 1.4 \text{ ps}$
 - ▶ Method: RDDSA
 - ▶ Main source of systematic uncertainty: Lifetimes of higher lying states
- ▶ Our method: DDCM in coincidence mode
 - ▶ Only depend on direct measurable quantities
 - ▶ Gating removes 3 out of the 4 contaminating components.

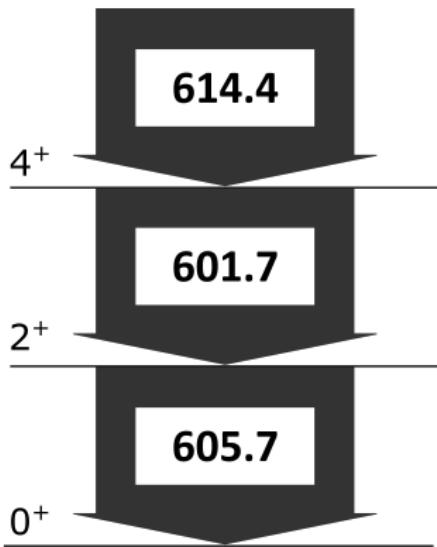


Figure 5: Three lowest transitions in the ground state band of ^{118}Te .

^aPasternak, A. A. et al. (2002).
Eur. Phys. J. A, 13(4), 435–448.

Gating removes 3 out of the 4 contaminating components

Differential Decay Curve Method (DDCM)^a in coincidence mode

$$\tau(x) = \frac{\{B_s, A_u\}(x)}{\frac{d}{dx} \{B_s, A_s\}(x)} \cdot \frac{1}{v}$$

$\{X, Y\}$: Area of peak Y, while gating on peak X

^aDewald, A., Möller, O., & Petkov, P. (2012). *Prog. Part. Nucl. Phys.*, 67(3): 786–839

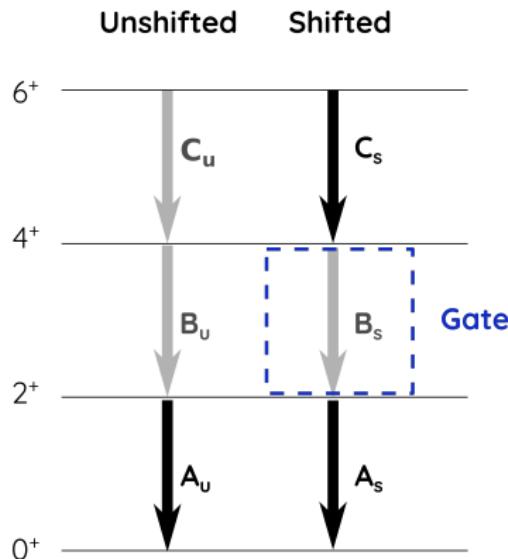
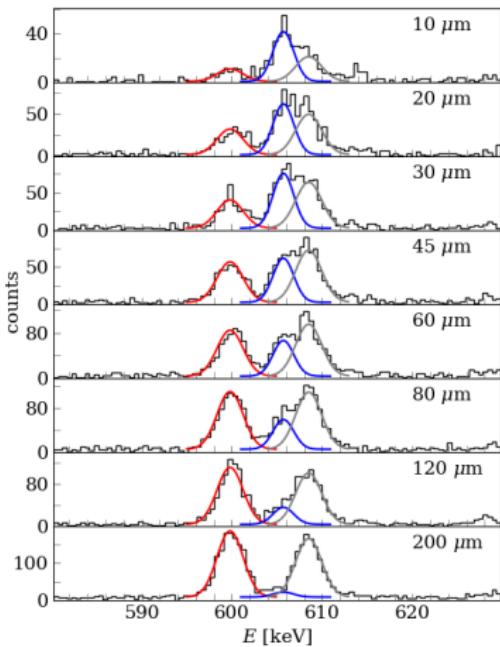


Figure 6: Schematic figure of the gate and resulting visible transitions (in black)

Example gated spectra with fit

Figure: Ring 2 vs ring 2 example. Shifted component of $2^+ \rightarrow 0^+$ transition (red), unshifted component of $2^+ \rightarrow 0^+$ (blue), contaminating peak (grey)



Lifetime deduced for two different ring combinations

$$\bar{\tau} = 8.4 \pm 0.5 \text{ ps}, \quad B(E2 \uparrow) = 0.59 \pm 0.03 \text{ e}^2\text{b}^2$$

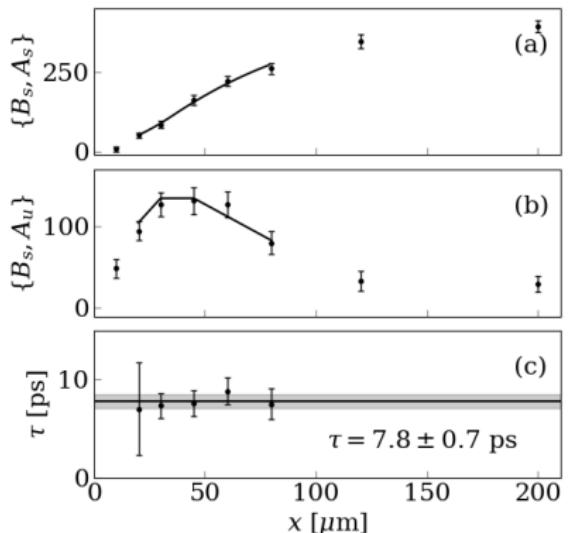


Figure 7: Ring 1 vs ring 2

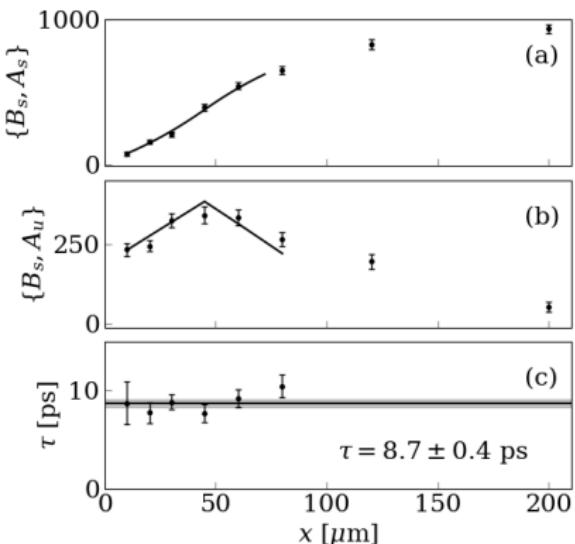


Figure 8: Ring 2 vs ring 2

New $B(E2)$ value preliminary confirms the dip in midshell

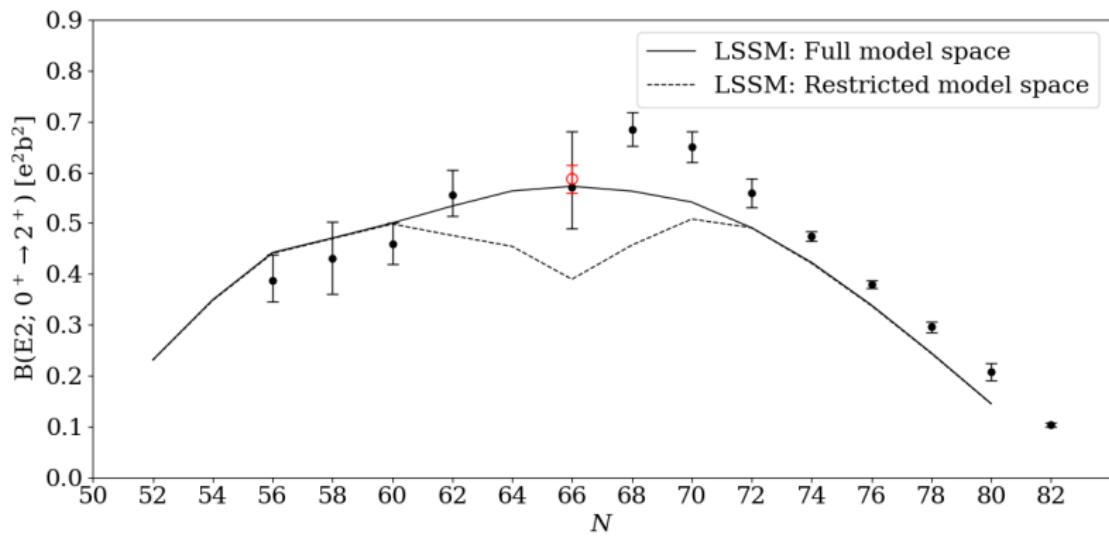


Figure 9: Currently adopted $B(E2)$ values for Te isotopic chain (black points) together with our preliminary value for ^{118}Te (red circle). LSSM calculations using full model space (solid line)³ and restricted model space in midshell⁴ (dashed line)

³Qi, C. (2016) *Phys. Rev. C*, 94(3):1–6

⁴Doncel, M. et al (2015), *Phys. Rev. C*, 91(6): 1–4

Summary

- ▶ The $B(E2)$ in midshell allow testing of shell model parameters
- ▶ Preliminary results $\tau = 8.4(5)$ ps
 - ▶ Reduction of relative uncertainty from 16% to 6%
 - ▶ Indicate a dip in midshell Te $B(E2; 0^+ \rightarrow 2^+)$
- ▶ Manuscript in preparation

Collaborators

Ahlgren Cederlöf, E.	Jakobsson, U.	Pranav, S.
Atac Nyberg, A.	Johnson, A.	Qi, C.
Auranen, K.	Julin, R.	Quintana, B.
Badran, H.	Juutinen, S.	Rahkila, P.
Braunroth, T.	Konki, J.	Ruotsalainen, P.
Bäck, T.	Leino, M.	Sandzelius, M.
Calverley, T.	Li, H.	Sarén, J.
Cederwall, B.	Liotta, R.	Scholey, C.
Cox, D.	Martin, S.	Singh, N.
Cullen, D. M.	Matta, S.	Sorri, J.
Doncel, M.	Modamio, V.	Stolze, S.
Grahn, T.	Nyberg, J.	Taylor, M. J.
Greenlees, P.	Pakarinen, J.	Uusitalo, J.
Herzáň, A.	Papadakis, P.	Valiente, J.
Hilton, J.	Partanen, J.	
Hodge, D.	Peura, P.	

Extra Slides

Other ring combinations

Rings (Gate, fit)	τ (ps)
(R1, R2)	7.8 ± 0.7
(R2, R1)	8.0 ± 1.1
(R2, R2)	8.7 ± 0.4
(R1, R1)	-

Table 1: Measured τ for different ring combinations. (R1, R1) contained too little statistics to produce a result.

Previous measurement of 2+ state of ^{118}Te

Pasternak, A. A. et al. (2002), *Eur. Phys. J. A*, 13(4), 435–448:

- ▶ $^{109}\text{Ag}(\text{C}^{13}, \text{p}3\text{n})$
- ▶ Beam energy 54 MeV
- ▶ NORDBALL + plunger

Velocity determination

$$\frac{E_0}{E} = 1 - \beta \cos \theta$$

$$\beta = 1.37(2)\%$$

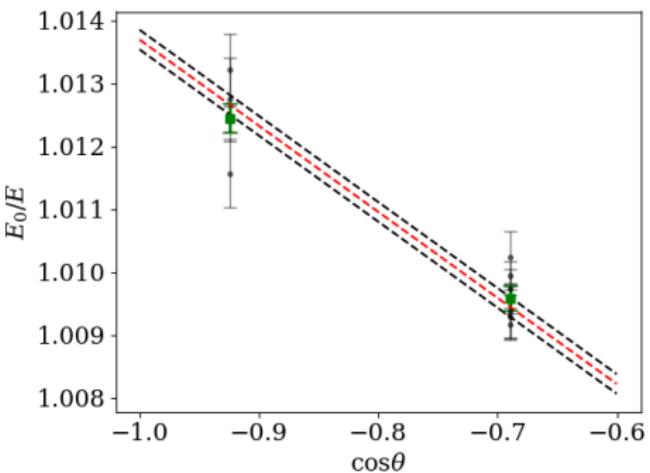


Figure 10: Unshifted energy over shifted energy plotted as a function of $\cos \theta$ (Black points) together with the weighted mean values for each ring (green squares). Red dotted line show the curve using the weighted mean value for β of all points, black dashed lines indicate 1σ .

Level scheme

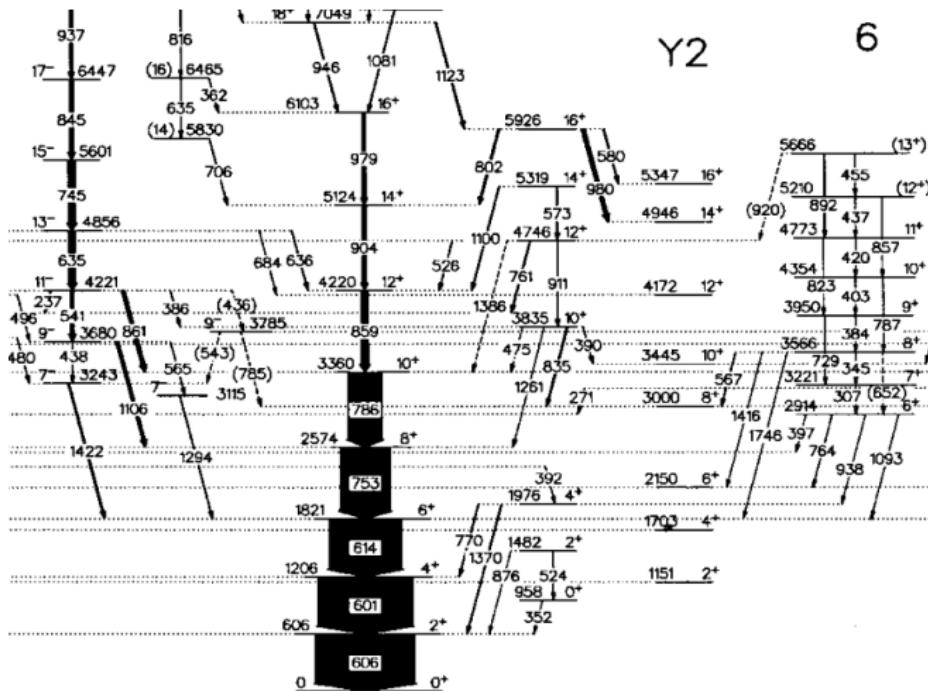


Figure 11: Part of level scheme for ^{118}Te . Taken from Juutinen, S. et al (2000), *Phys. Rev. C*, 61(1), 17.

Gate

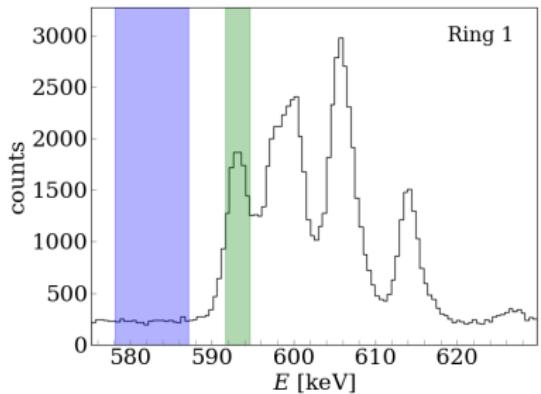


Figure 12: Ring 1, $x = 200\mu\text{m}$. Green: gate (6 channels), blue: background gate

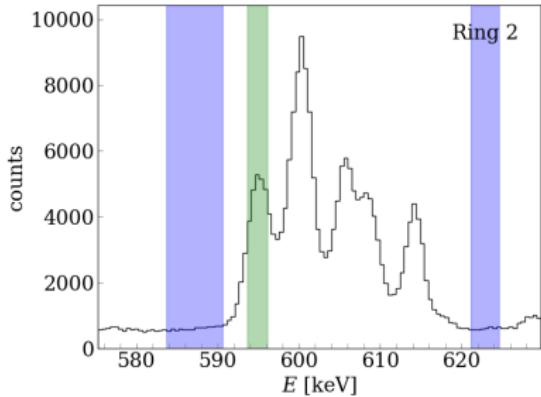


Figure 13: Ring 2, $x = 200\mu\text{m}$. Green: gate (5 channels), blue: background gate

LSSM calculation in Fig. 9

Full model space:

Qi, C. (2016), *Phys. Rev. C*, 94(3): 1–6:

- ▶ ^{100}Sn inert core
- ▶ Neutron and proton orbitals: $0g_{7/2}$, $1d_{5/2}$, $1d_{3/2}$, $2s_{1/2}$, and $0h_{11/2}$
- ▶ $e_p = 1.5e$ and $e_n = 0.8e$

Restricted model space in midshell:

Doncel, M. et al (2015), *Phys. Rev. C*, 91(6): 1–4:

Maximum number of particles (protons and neutrons) allowed to be excited to $h_{11/2}$

- ▶ $N = 62 - 68$: max 4
- ▶ $N = 70$: max 6
- ▶ $N = 72$: max 10

Data analysis steps

- ▶ Determine velocity of recoils
- ▶ Determine shifted and unshifted peak widths and positions
- ▶ Set peak gate and background gate
- ▶ Perform background subtraction
- ▶ Fit peaks
 - ▶ Fixed: Peak widths and positions
- ▶ Normalize the areas
- ▶ Calculate lifetime and $B(E2)$