Survey of Experimental Uncertainties in Recent Literature

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Motivation

- Ongoing discussion on averaging procedures
- Essential item to understand is “type” of uncertainty
- After NSDD and subsequent email discussions, volunteered to “keep track” of uncertainties through XUNDL compilations for PRC

Good news : about 1/3 of articles discuss and divide their uncertainties

Also good news : we can probably infer uncertainty components in similar papers

Caveats :

1) Only looked at a few basic properties
2) This is just a few months of PRC articles
3) Took directly from authors statistical versus systematic definitions

Gamma ray energies – high statistics

PHYSICAL REVIEW C **110**, 024305 (2024)

Detailed spectroscopy and γ-γ angular correlation measurements of ^{122}Xe

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D. S. Cross,[5] A. B. Garnsworthy,[6] B. Hadinia,[1,†] S. F. Hicks,[7,8] M. Moukaddam,[6,‡] J. Park,[6,9,§] J. L. Pore,[5,‖]
M. M. Rajabali,[6,¶] E. T. Rand,[1,#] U. Rizwan,[5] C. E. Svensson,[1] P. Voss,[5,**] Z. M. Wang,[5,6] J. L. Wood,[10] and S. W. Yates[8]

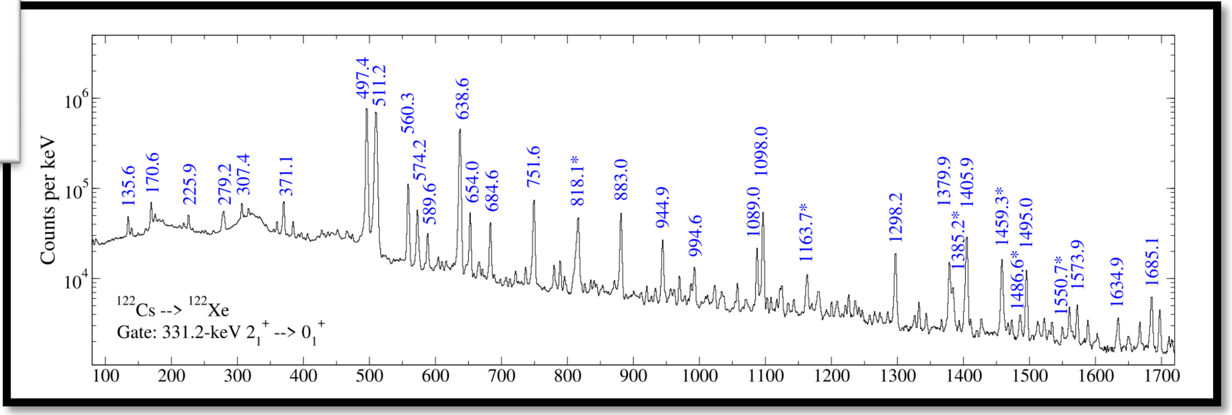

TABLE I. Levels and observed γ rays in ^{122}Xe populated in the β^+/EC decay of ^{122}Cs 1^+ ground state. The intensity (I_γ) of each γ ray is given relative to that of the 331 keV $2_1^+ \rightarrow 0_1^+$ γ ray defined to be 10 000 units. The normalization factor for converting the relative to absolute β-feeding intensities is 0.009 05(16). The log ft values are lower limits on an absolute scale. All γ-ray energies include statistical uncertainties, and an additional systematic uncertainty of 0.2 keV has not been accounted for.

E_{initial} (keV)	j_i^π	E_γ (keV)	E_{final} (keV)	j_f^π	I_γ	ML	δ	BR	I_β	log ft
331.26(9)	2^+	331.24(3)	0.0	0^+	10000	$E2$		100	26.2(10)	7.60(1)
828.61(10)	4^+	497.41(3)	331.26(9)	2^+	226(5)	$E2$		100	0.61(6)	9.06(3)
843.19(9)	2^+	511.21(3)	331.26(9)	2^+	<2107(65)	$M1, E2$		<84.3(4)	<16.6(7)	>7.62(2)
		843.16(4)	0.0	0^+	393(8)			>15.7(4)		
1149.31(11)	0^+	306.12(15)	843.19(9)	2^+	17.1(13)	$E2$		2.2(2)	7.37(16)	7.86(1)
		818.14(3)	331.26(9)	2^+	751.0(48)	$E2$		97.8(2)		
1214.28(10)	3^+	371.08(4)	843.19(9)	2^+	97.5(27)	$M1, E2$	$8.6^{+6.7}_{-2.7}$	30.7(7)	1.33(6)	8.57(2)
		385.69(6)	828.61(10)	4^+	26.1(9)	$M1, E2$	$2.8^{+0.5}_{-0.4}$	8.2(2)		
		883.00(3)	331.26(9)	2^+	194.2(42)	$M1, E2$	$0.05^{+0.04}_{-0.04}$	61.1(13)		
1402.82(12)	4^+	559.64(6)	843.19(9)	2^+	14.0(4)	$E2$		53.0(5)	0.057(17)	9.86(13)
		574.19(4)	828.61(10)	4^+	12.38(30)	$M1, E2$	$3.0^{+3.3}_{-1.3}$	47.0(5)		

Statistical uncertainties are <0.1 keV
(as expected)
Systematic uncertainties are 0.2 keV

Gamma ray energies – high statistics

(no detailed description of uncertainties)

PHYSICAL REVIEW C **109**, 054317 (2024)

Low-spin states in ^{118}Sn populated by the radiative capture of thermal neutrons

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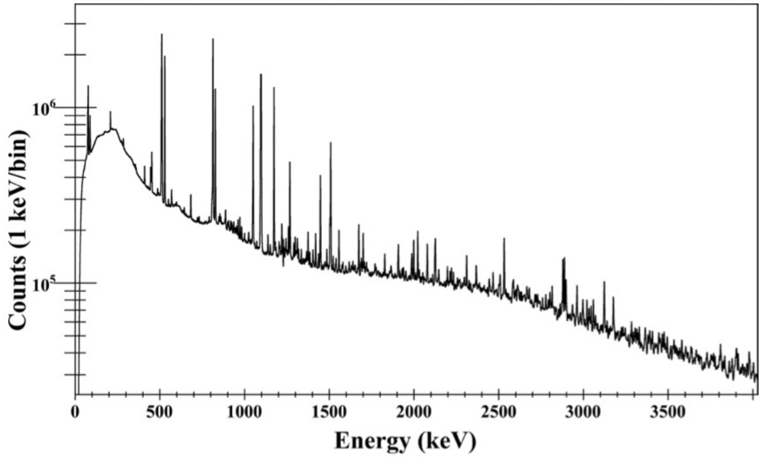
TABLE I. Observed levels and transitions from the present $^{117}\mathrm{Sn}(n,\gamma)^{118}\mathrm{Sn}$ experiment. Level energies were fit to the γ-ray transition energies using a least-squares fit. The energies in bold are the newly placed transitions and levels which are not in the current Evaluated Nuclear Structure Data File (ENSDF) sheet [24]. Spins of newly placed states are given based on γ decay selection rules. Branching ratios are compared to a previous high-statistics study involving β decay of the 5^+ isomer of ^{118}In [10].

$E_{\mathrm{level},i}$ (keV)	J_i^π	$E_{\mathrm{level},f}$ (keV)	J_f^π	E_γ (keV)	I_γ	$I_\gamma^{\mathrm{norm.}}$	$I_\gamma^{\mathrm{norm.}}$ [10]
1229.50(7)	2^+	0	0^+	1229.7(3)	100	100	100
1758.08(9)	0^+	1229.50	2^+	528.9(3)	6.5(2)	100	100
2042.67(8)	2^+	1758.08	0^+	284.5(3)	0.12(3)	1.1(3)	1.31(17)
		1229.50	2^+	813.3(3)	11.3(4)	100(3)	100.0(23)
		0	0^+	2042.9(3)	8.3(3)	74(3)	83.6(26)
2056.66(9)	0^+	1229.50	2^+	827.3(3)	5.26(18)	100	
2280.23(14)	4^+	1229.50	2^+	1050.7(3)	5.31(17)	100	100
2321.1(2)	5^-	2280.23	4^+	41.0(3)		100(3)	
		1229.50	2^+	1091.5(3)		8.6(9)	
2324.77(10)	3^-	1229.50	2^+	1095.2(3)	9.1(3)	100	100(5)
2327.82(9)	2^+	2042.67	2^+	285.2(3)	0.156(19)	1.69(20)	2.3(8)
		1758.08	0^+	569.6(3)	0.255(12)	2.76(13)	2.40(14)
		1229.50	2^+	1098.4(3)	9.2(3)	100(4)	100(4)
		0	0^+	2328.0(3)	1.52(8)	16.6(8)	19.1(8)
2403.01(9)	2^+	2042.67	2^+	360.4(3)	0.102(9)	1.29(12)	0.91(13)
		1758.08	0^+	644.8(3)	0.108(9)	1.36(11)	1.44(6)
		1229.50	2^+	1173.7(3)	7.9(4)	100(4)	100.0(26)
2488.57(14)	4^+	2280.23	4^+	208.6(3)	0.372(13)	47.3(16)	60.3(12)
		2042.67	2^+	446.0(3)	0.79(5)	100(6)	100.0(22)
		1229.50	2^+	1259.1(3)	0.54(9)	69(12)	59.2(16)



- 10 Pages of Tables
- Majority of transitions have 0.3 keV uncertainty
- Some have 0.4 or 0.5 keV uncertainty
- Probably safe to infer that 0.3 keV is the systematic uncertainty

Gamma ray energies – low statistics

PHYSICAL REVIEW C **110**, 014331 (2024)

First high-resolution γ-ray spectroscopy of ^{41}Si

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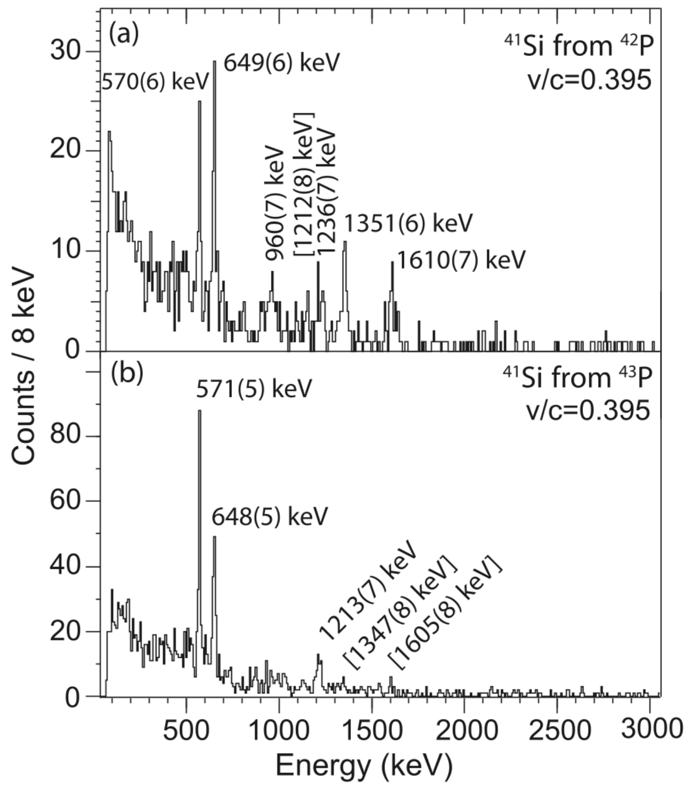
GRETINA + S800 at MSU
This is the “future” data



Reported uncertainties on gamma ray energies are 5 -10 keV but type not specified

From A. Gade:

- uncertainty includes statistical and systematic
- systematic uncertainty is dominant, from several contributions, including calibration, beam position (mid-target assumed), beam velocity, etc.

Ground state half-lives

PHYSICAL REVIEW C **109**, 055501 (2024)

Editors' Suggestion

Half-life of ^{71}Ge and the gallium anomaly

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III. CONCLUSIONS

Finally, combining the statistical and systematic uncertainties, we determine the half-life of ^{71}Ge to be

$$t_{1/2}(^{71}\mathrm{Ge}) = 11.4683 \pm 0.0017(\mathrm{stat.}) \pm 0.0082(\mathrm{syst.})$$
$$= 11.468 \pm 0.008\ \mathrm{days}$$

0.015% statistical

0.075% systematic

Excited State Half-lives

PHYSICAL REVIEW C **109**, 044307 (2024)

Analog $B(M1)$ strengths in the $T_z = \pm\frac{3}{2}$ mirror nuclei ^{47}Mn and ^{47}Ti

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the six-channel region described above. This increases the lifetime by 5 ps, and was also included as an additional systematic error. The total systematic error is then 14 ps. By adding both the statistical and systematic errors in quadrature, this yields a lifetime of $\tau = 331 \pm 4$ (stat.) ± 14 (sys.) ps [$T_{\frac{1}{2}} = 229(10)$ ps] for the $\frac{7}{2}^-_1$ state.

tematic error of 1.6%). The final systematic error is therefore 32 ps. This yields a final result of $\tau = 687 \pm 17$ (stat.) $\pm$ 32 (sys.) ps. The γ-ray energy had the same 0.3 keV statistical

Systematic uncertainty roughly twice that of statistical

PHYSICAL REVIEW C **109**, L061301 (2024)

Letter

New isomeric transition in ^{36}Mg: Bridging the $N = 20$ and $N = 28$ islands of inversion

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feeding said first 2^+ state. The analysis of the time structure of 168-keV γ-ray events following the ion implantation results in a half-life of $T_{1/2} = 90(^{+410}_{-50})_{\rm stat}(\pm 40)_{\rm tran}(^{+800}_{-70})_{\rm sys}$ ns ("tran" corresponds to the uncertainty due to the transit time A1900, see below). We present an interpretation of the nature

Systematic uncertainty roughly twice that of statistical

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More Excited State Half-lives - DSAM

PHYSICAL REVIEW C **109**, L051303 (2024)

Letter

Evidence for octupole correlation in $Z = 50$ Sn isotopes: Spectroscopy of ^{112}Sn

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TABLE I. The present measured lifetimes τ, the previous lifetime results in Ref. [8], γ-ray energies (E_γ), the relative intensities (I_γ), and the reduced transition probabilities $B(E2)$ and $B(E1)$ for bands 1 and 2 in ^{112}Sn. Uncertainties in the present measured lifetimes do not include the systematic errors that are associated with the stopping powers, which may be as large as $\pm15\%$. The relative intensity of the 1256 keV γ ray in Fig. 1 is taken as 100.

band	$I_i(\hbar)$	τ (ps)	τ (ps) [8]	E_γ (keV)	I_γ	$\sigma\lambda$	$B(\sigma\lambda)$ (W.u.)
1	12^+		0.95 ± 0.20	744.3	30.6(3.0)	$E2$	
	14^+	$1.53^{+0.10}_{-0.03}$	[illegible]	[illegible]	27.7(2.7)	$E2$	49^{+1}_{-4}
			[illegible]	[illegible]	1.5(0.2)	$E2$	6^{+2}_{-2}
	16^+	$1.30^{+0.08}_{-0.05}$	[illegible]	[illegible]	20.9(2.6)	$E2$	42^{+2}_{-3}
				728.2	0.9(0.1)	$E2$	4^{+1}_{-1}
	18^+	$0.50^{+0.02}_{-0.01}$	[illegible]	[illegible]	18.2(1.9)	$E2$	72^{+2}_{-2}
	20^+	$0.35^{+0.01}_{-0.01}$	[illegible]	[illegible]	8.8(0.9)	$E2$	60^{+2}_{-2}
2	15^-	$0.94^{+0.04}_{-0.06}$	[illegible]	[illegible]	10.8(1.1)	$E2$	61^{+8}_{-6}
				845.1	0.9(0.2)	$E1$	$(5^{+2}_{-2}) \times 10^{-5}$
				706.7	2.2(0.3)	$E2$	24^{+8}_{-5}
	17^-	$0.73^{+0.02}_{-0.02}$		875.8	6.8(0.7)	$E2$	58^{+4}_{-4}
				869.8	0.8(0.1)	$E1$	$(9^{+2}_{-2}) \times 10^{-5}$
				283.5	0.3(0.1)	$M1/E2$	
	18^-	$0.66^{+0.06}_{-0.06}$		899.9	6.8(0.7)	$E2$	65^{+7}_{-5}
	19^-	$0.56^{+0.04}_{-0.04}$		961.5	3.5(0.4)	$E2$	49^{+6}_{-5}
				899.4	0.4(0.1)	$E1$	$(11^{+4}_{-4}) \times 10^{-5}$
	20^-	$0.46^{+0.02}_{-0.02}$		974.0	2.2(0.2)	$E2$	63^{+3}_{-3}
	21^-	$0.35^{+0.05}_{-0.04}$		1029.4	1.3(0.2)	$E2$	39^{+12}_{-10}
				890.2	0.3(0.1)	$E1$	$(24^{+16}_{-11}) \times 10^{-5}$
				400.4	0.5(0.1)	$M1/E2$	
	22^-	$0.36^{+0.04}_{-0.04}$		997.7	1.4(0.2)	$E2$	71^{+9}_{-7}

Statistical 3-10%

Systematic ~15%

PHYSICAL REVIEW C **109**, 064311 (2024)

Extended level structure of ^{51}Cr with measured mean lifetimes of yrast states in agreement with shell-model calculations

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in the vicinity of the minimum. However, the systematic error that is associated with the modeling of the stopping power, and which can be as large as 10–15%, is not included in the quoted errors (Table II). The mean lifetime (τ) of the newly observed

Spin ($\hbar$)	Level energy E_x (keV)	Lifetime τ (ps) Expt.	Theo.[c]
$\frac{9}{2}^-_1$	1164.52(9)	0.11(1)[a]	0.08
$\frac{11}{2}^-_1$	1480.12(9)	0.79^{+35}_{-6}[a]	1.17
$\frac{15}{2}^-_1$	2255.53(13)	66.1(20)[a]	41.45
$\frac{17}{2}^-_1$	3181.14(16)	0.08(2)[d]	0.08
$\frac{19}{2}^-_1$	3818.05(18)	0.31(3)	0.33
$\frac{21}{2}^-$	5564.47(21)	0.07(1)	0.06
$\frac{23}{2}^-_1$	5714.08(20)	0.42(5)	0.27
$(\frac{25}{2})^-_1$	8491.8(4)	0.11(3)	0.13