β-decay study of very neutron-rich indium isotopes

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IS610 and IDS Collaborations

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Seminarium Fizyki Jądra Atomowego

9 grudnia 2021, *online*

Presentation outline

β-decay study of very neutron-rich indium isotopes

New β-decay branches of ^{134}In and first β-decay spectroscopy of ^{135}In

1. Motivation: astrophysics, nuclear structure
2. Previous studies: In and Sn isotopes beyond $N = 82$
3. Experiment: β-delayed γ-ray spectroscopy

   ISOLDE Decay Station
4. Results and discussion
5. Summary and outlook

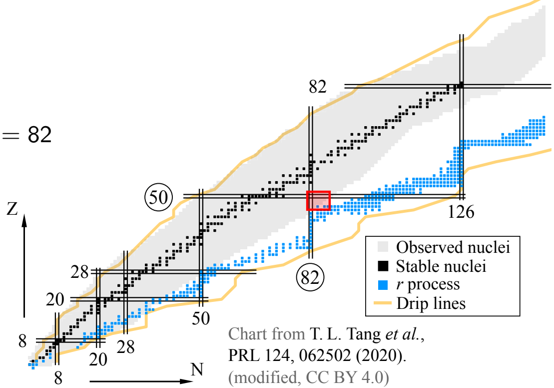
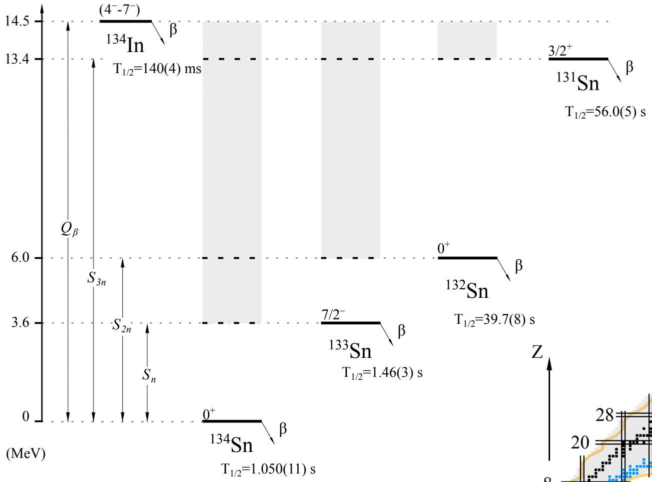


Chart from T. L. Tang *et al.*, PRL 124, 062502 (2020). (modified, CC BY 4.0)

Introduction: exotic nuclei around ^{132}Sn



M. Wang *et al.*, Chin. Phys. C 41, 030003 (2017).

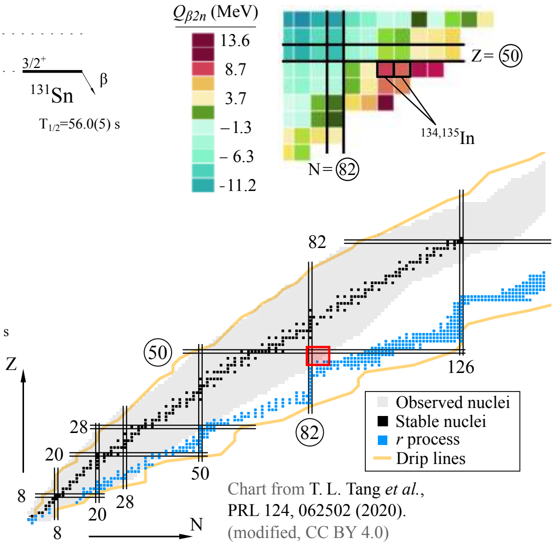
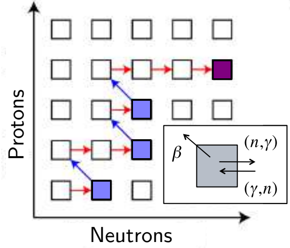
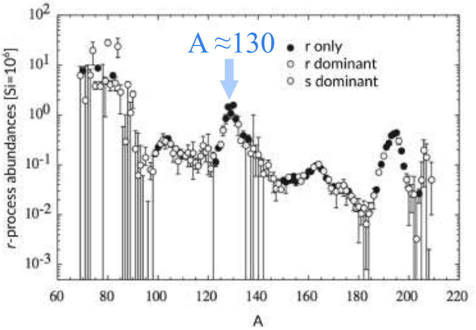


Chart from T. L. Tang *et al.*, PRL 124, 062502 (2020). (modified, CC BY 4.0)

Introduction: exotic nuclei around ^{132}Sn





M.Arnould *et al.*,
Phys. Rep. 450,
97 (2007).

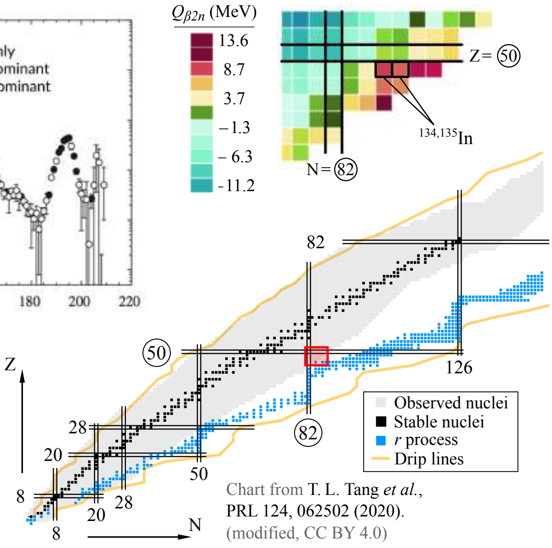


Chart from T. L. Tang *et al.*,
PRL 124, 062502 (2020).
(modified, CC BY 4.0)

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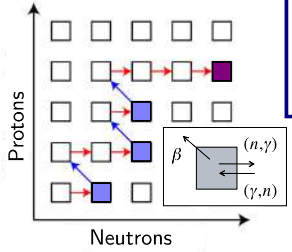
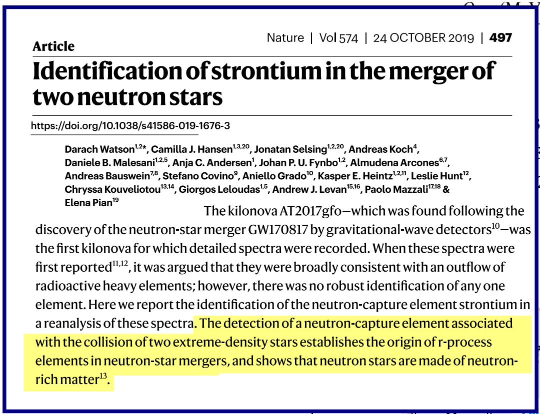




Article

Nature | Vol 574 | 24 OCTOBER 2019 | **497**

Identification of strontium in the merger of two neutron stars

https://doi.org/10.1038/s41586-019-1676-3

Darach Watson[1,2*], Camilla J. Hansen[1,3,20], Jonatan Selsing[1,2,20], Andreas Koch[4], Daniele B. Malesani[1,2,5], Anja C. Andersen[1], Johan P. U. Fynbo[1,2], Almudena Arcones[6,7], Andreas Bauswein[7,8], Stefano Covino[9], Aniello Grado[10], Kasper E. Heintz[1,2,11], Leslie Hunt[12], Chryssa Kouveliotou[13,14], Giorgos Leloudas[1,5], Andrew J. Levan[15,16], Paolo Mazzali[17,18] & Elena Pian[19]

The kilonova AT2017gfo—which was found following the discovery of the neutron-star merger GW170817 by gravitational-wave detectors[10]—was the first kilonova for which detailed spectra were recorded. When these spectra were first reported[11,12], it was argued that they were broadly consistent with an outflow of radioactive heavy elements; however, there was no robust identification of any one element. Here we report the identification of the neutron-capture element strontium in a reanalysis of these spectra. The detection of a neutron-capture element associated with the collision of two extreme-density stars establishes the origin of r-process elements in neutron-star mergers, and shows that neutron stars are made of neutron-rich matter[13].

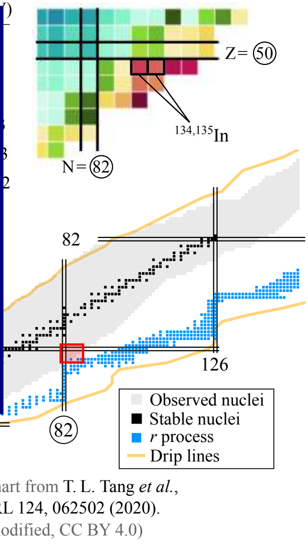


Chart from T. L. Tang *et al.*, PRL 124, 062502 (2020). (modified, CC BY 4.0)

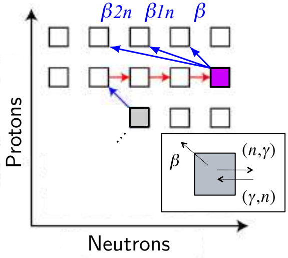
Introduction: exotic nuclei around ^{132}Sn

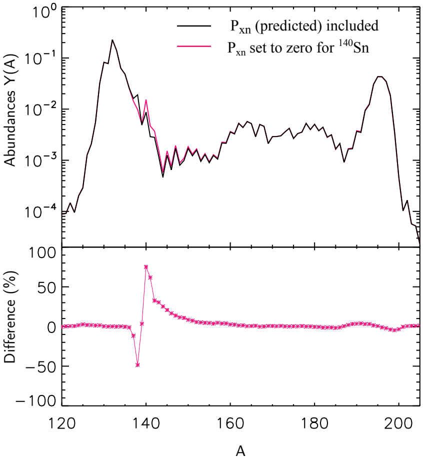
The sensitivity of r-process nucleosynthesis to βn emission

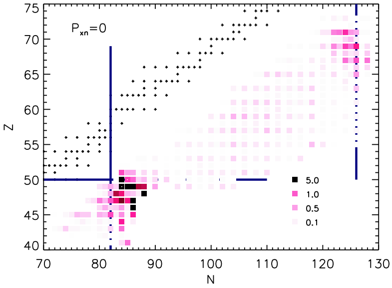
Sensitivity measure F:

$$F = 100 \times \sum_A |X(A)_{P_{xn}=0} - X(A)|$$

one βxn emitter "turned off" *baseline*

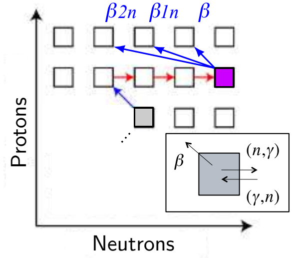


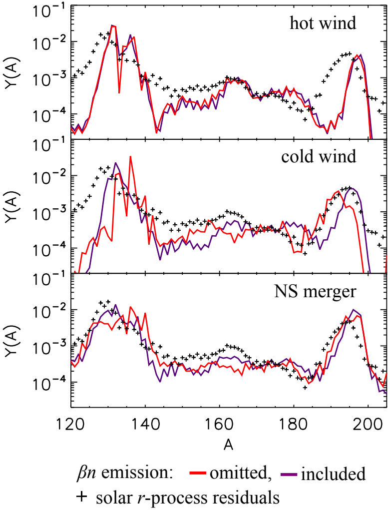


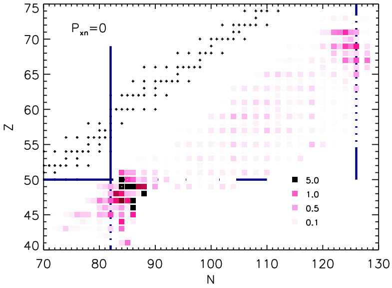


R. Surman *et al.*, JPS Conf. Proc. 6, 010010 (2015).

Introduction: exotic nuclei around ^{132}Sn

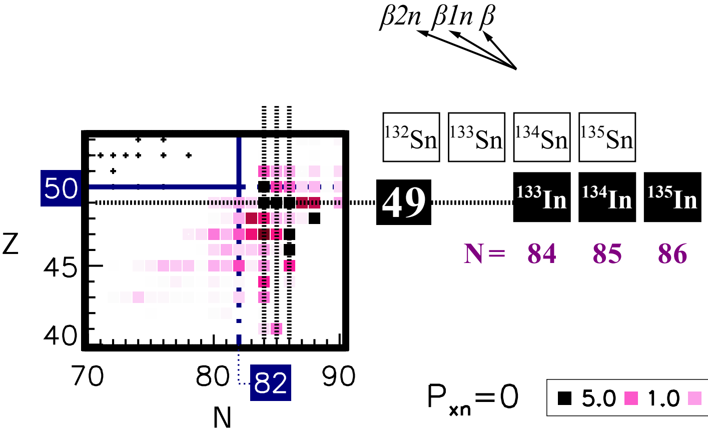


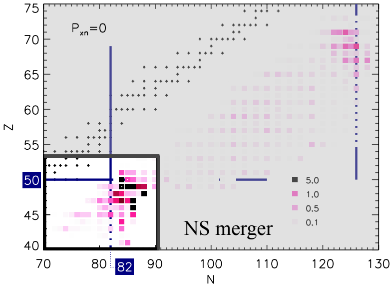




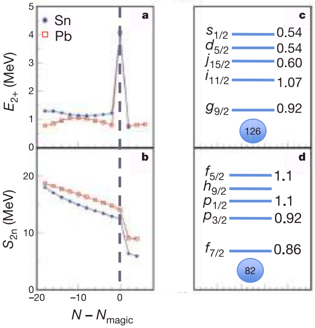
R. Surman *et al.*, JPS Conf. Proc. 6, 010010 (2015).

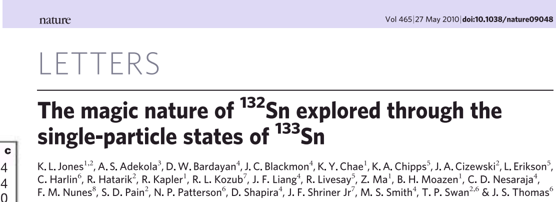
Introduction: exotic nuclei around ^{132}Sn





Introduction: simple nuclei around ^{132}Sn





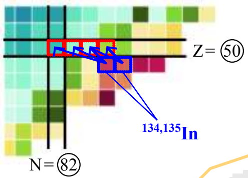
nature

Vol 465 | 27 May 2010 | doi:10.1038/nature09048

LETTERS

The magic nature of ^{132}Sn explored through the single-particle states of ^{133}Sn

K. L. Jones[1,2], A. S. Adekola[3], D. W. Bardayan[4], J. C. Blackmon[4], K. Y. Chae[1], K. A. Chipps[5], J. A. Cizewski[2], L. Erikson[5], C. Harlin[6], R. Hatarik[2], R. Kapler[1], R. L. Kozub[7], J. F. Liang[4], R. Livesay[5], Z. Ma[1], B. H. Moazen[1], C. D. Nesaraja[4], F. M. Nunes[8], S. D. Pain[2], N. P. Patterson[6], D. Shapira[4], J. F. Shriner Jr[7], M. S. Smith[4], T. P. Swan[2,6] & J. S. Thomas[6]



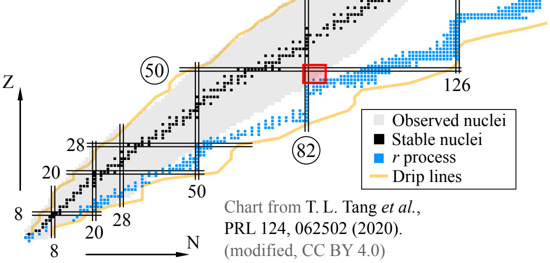
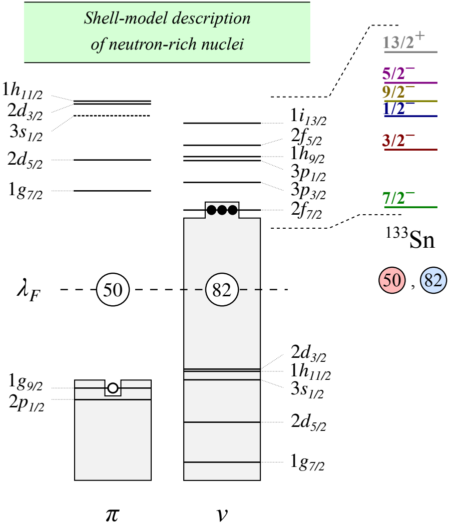


Chart from T. L. Tang *et al.*, PRL 124, 062502 (2020). (modified, CC BY 4.0)

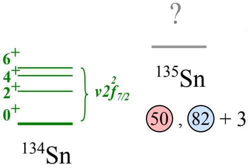
Introduction: simple nuclei around ^{132}Sn

Shell-model description of neutron-rich nuclei



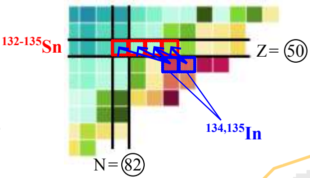
^{133}Sn

㊿, (82) + 1 ← neutron single-particle energies



㊿, (82) + 3

㊿, (82) + 2 ← effective NN interactions



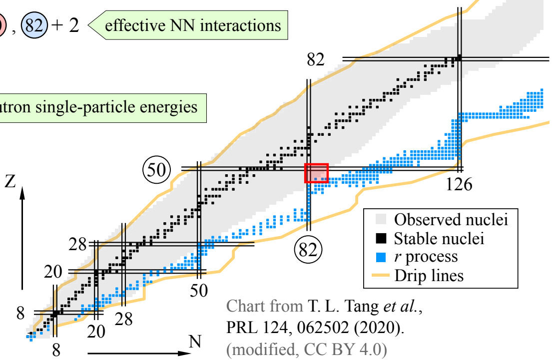
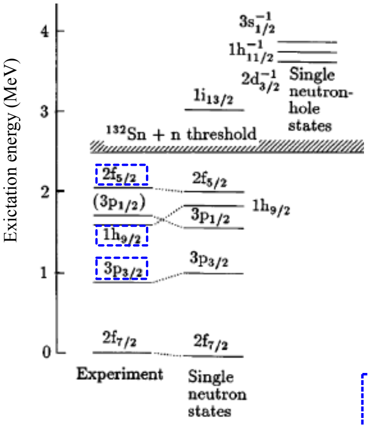


Chart from T. L. Tang *et al.*, PRL 124, 062502 (2020). (modified, CC BY 4.0)

Previous β-decay study of ^{134}In (1996)



^{133}Sn: (50), (82) + 1

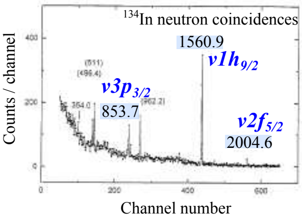
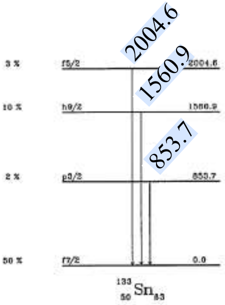


TABLE I. Data for γ transitions in ^{133}Sn.

Energy (keV)	^{134}In decay Neutron gated	Relative intensity ^{134}In decay β gated only
354.0(10)	2.3(7)	< 2
802.0(10)^{a}	2.1(10)	9(2)
853.7(3)	13(2)	23(2)
1560.9(5)^{b}	100(5)	100(4)
2004.6(10)	5.1(10)	26(3)

[b] The absolute intensity of this transition is (5–10)% per decay of ^{134}In



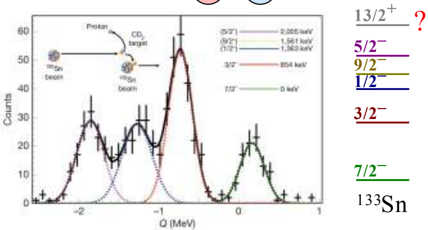
P_n (^{134}In)~65%

$T_{1/2}$(^{134}In)=138(8) ms

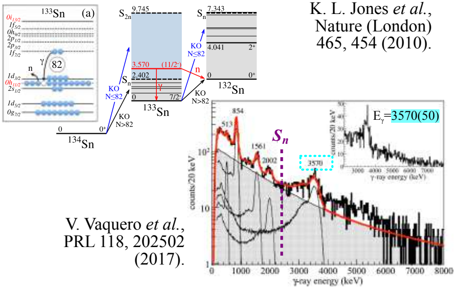
P. Hoff *et al.*, PRL 77, 1020 (1996).

Status: β-decay daughters of ^{134,135}In

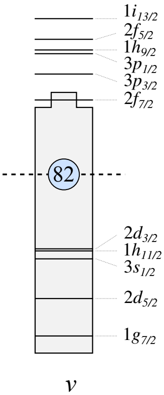
^{133}Sn: ㊿ , (82) + 1



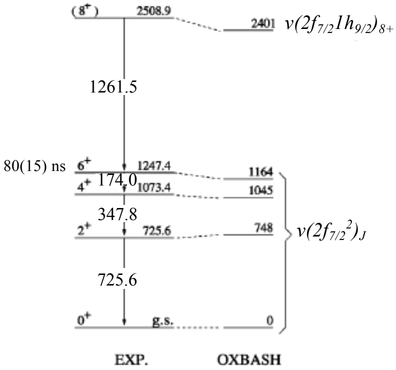
K. L. Jones *et al.*, Nature (London) 465, 454 (2010).



V. Vaquero *et al.*, PRL 118, 202502 (2017).



^{134}Sn: ㊿ , (82) + 2

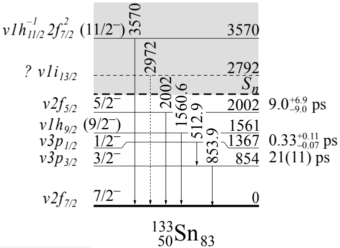


A. Korgul *et al.*, EPJA 7, 167 (2000).

Status: β-decay daughters of ^{134,135}In

^{133}Sn: ⑤⓪, ⑧② + 1

One-neutron transfer reactions



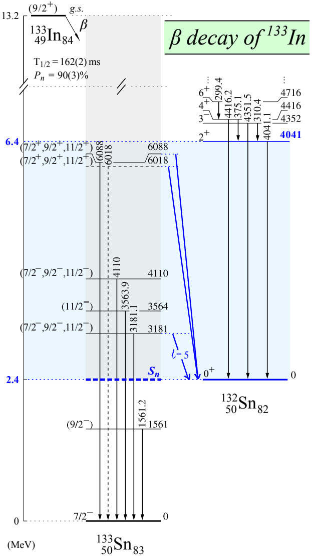
^{132}Sn$(d,p)^{133}$Sn
K. L. Jones *et al.*, Nature (London) 465, 454 (2010).

^{132}Sn(^{9}Be, ^{8}Be)^{133}Sn
J. M. Allmond *et al.*, PRL 112, 172701 (2014).

1*n* KO from ^{134}Sn
V. Vaquero *et al.*, PRL 118, 202502 (2017).

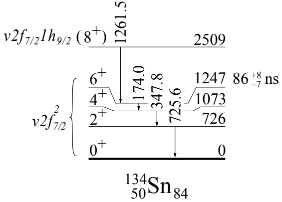
^{133}In β decay
MPS *et al.*, PRC 99, 024304 (2019).
J. Benito, ..., MPS *et al.*, PRC 102, 014328 (2020).
P. Hoff *et al.*, PRL 77, 1020 (1996).

β decay of ^{133}In



^{134}Sn: ⑤⓪, ⑧② + 2

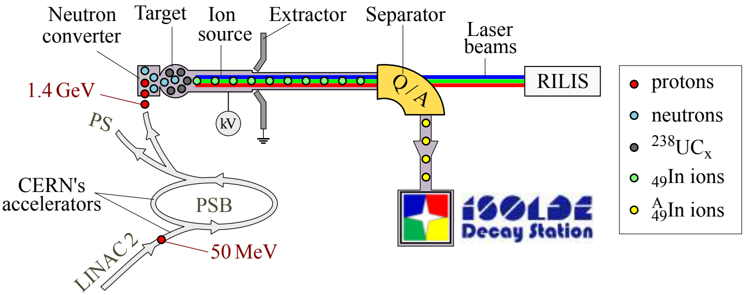
Fission studies

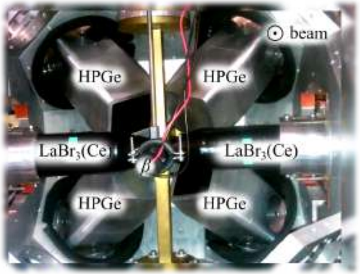


^{248}Cm *sf*
A. Korgul *et al.*, EPJA 7, 167 (2000).
C. T. Zhang *et al.*, Z. Phys. A 358, 9 (1997).

^{238}U *in-flight fission*
D. Kameda *et al.*, PRC 86, 054319 (2012).

Experiment: ISOLDE Decay Station





- IS610 experiment
- Spokespersons:

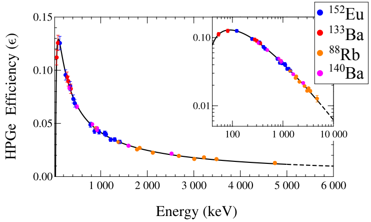
  L. M. Fraile
  (Univ. Complutense de Madrid)

  A. Korgul
  (Univ. Warsaw)

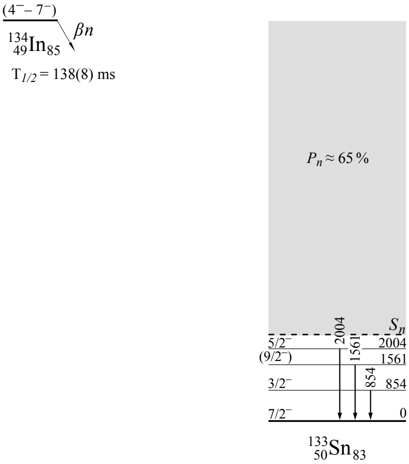
- Fast-timing campaigns in 2016 and 2018
- ^{132}Sn region: neutron-rich In isotopes

MPS *et al.*, PRC 104, 044328 (2021).
J. Benito, ..., MPS *et al.*, PRC 102, 014328 (2020).
MPS *et al.*, PRC 99, 024304 (2019).
MPS *et al.*, APPB 49, 523 (2018).

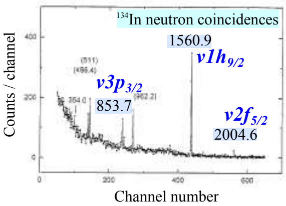
MPS, Phd thesis (Univ. Warsaw, 2021).
J. Benito, Phd thesis (Univ. Complutense de Madrid, 2020).



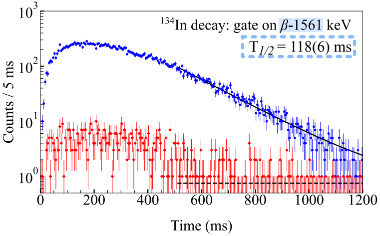
Status: β-decay scheme of ^{134}In

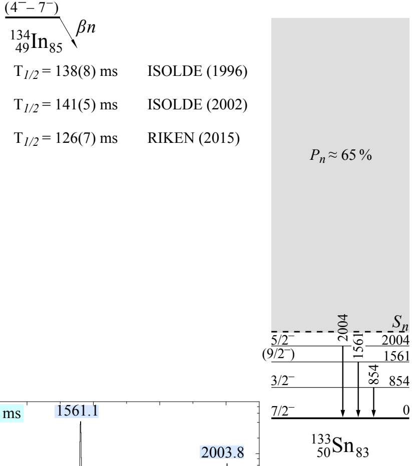


P. Hoff *et al.*, PRL 77, 1020 (1996).



Results: βn decay of ^{134}In

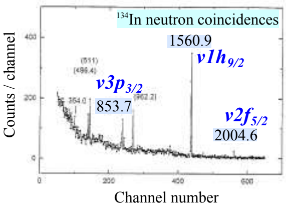


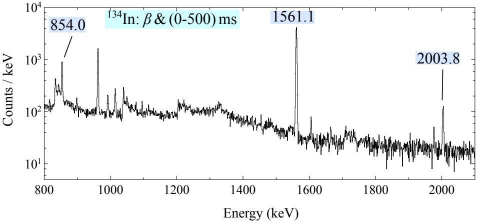


$T_{1/2}$ = 138(8) ms ISOLDE (1996)

$T_{1/2}$ = 141(5) ms ISOLDE (2002)

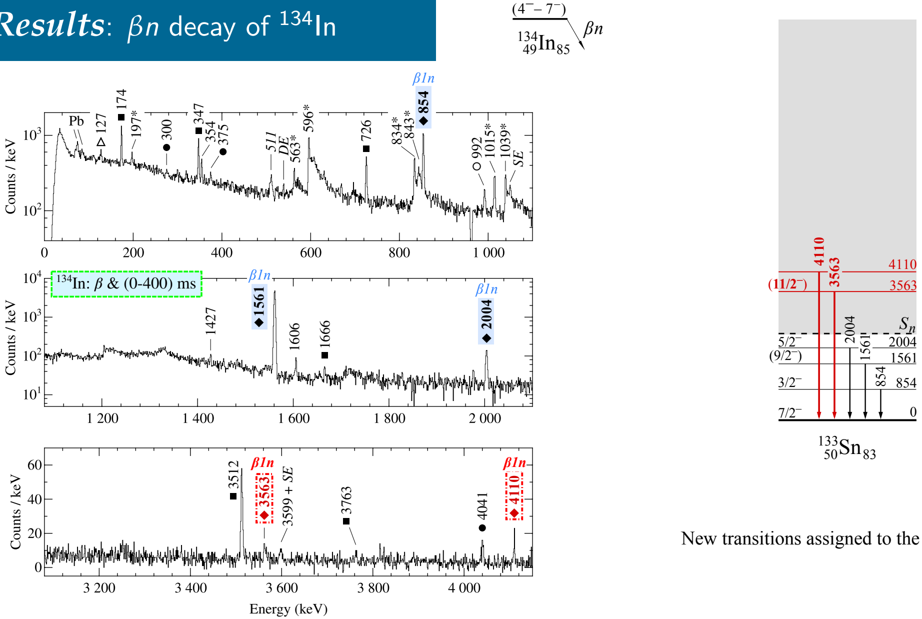
$T_{1/2}$ = 126(7) ms RIKEN (2015)





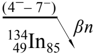
P. Hoff *et al.*, PRL 77, 1020 (1996).
I. Dillmann *et al.*, EPJA 13, 281 (2002).
G. Lorusso *et al.*, PRL 114, 192501 (2015).
M.P.S. *et al.*, PRC 104, 044328 (2021).

Results: βn decay of ^{134}In

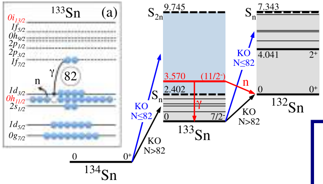


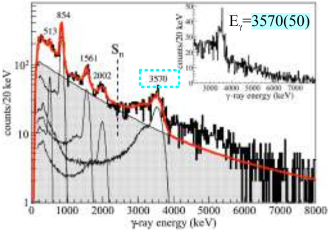
New transitions assigned to the $\beta 1n$-decay branch

Results: βn decay of ^{134}In



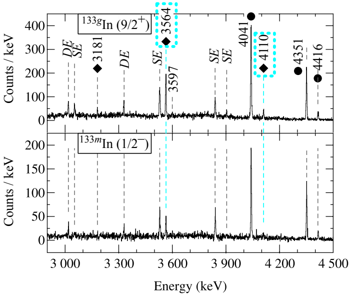
1n knockout from ^{134}Sn



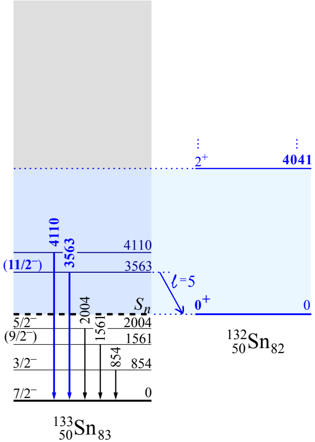


V. Vaquero *et al.,* PRL 118, 202502 (2017).

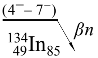
^{133}In β decay



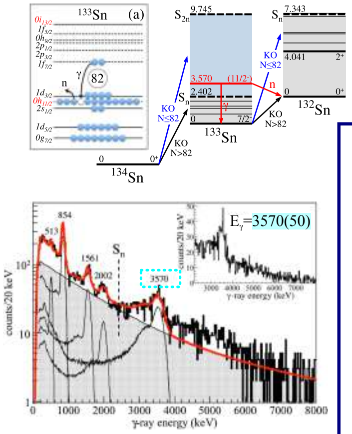
M.P. *et al.,* PRC 99, 024304 (2019).
J. Benito, ..., M.P. *et al.*, PRC 102, 014328 (2020).



Results: βn decay of ^{134}In

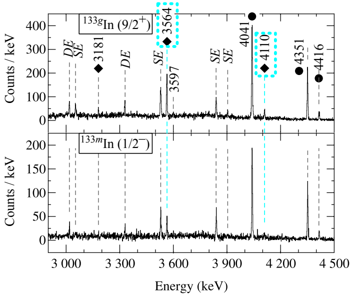


1n knockout from ^{134}Sn

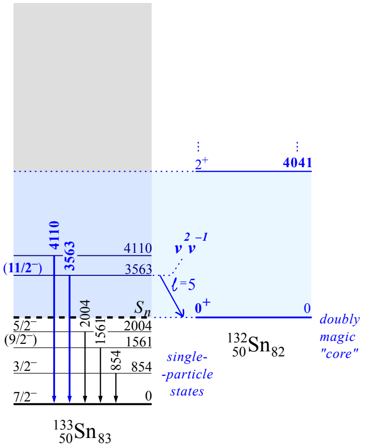


V. Vaquero *et al.,* PRL 118, 202502 (2017).

^{133}In β decay

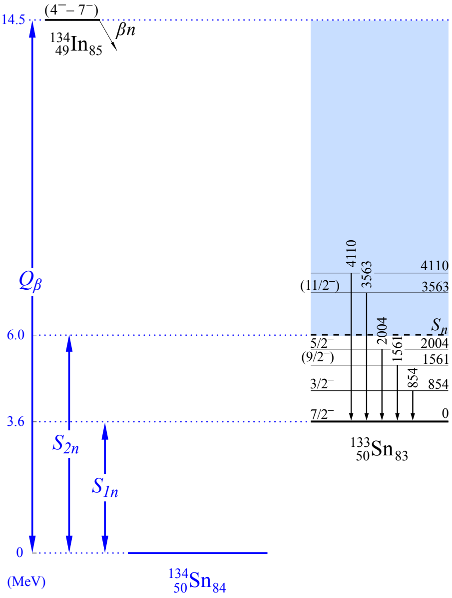


M.P. *et al.,* PRC 99, 024304 (2019).
J. Benito, ..., M.P. *et al.*, PRC 102, 014328 (2020).

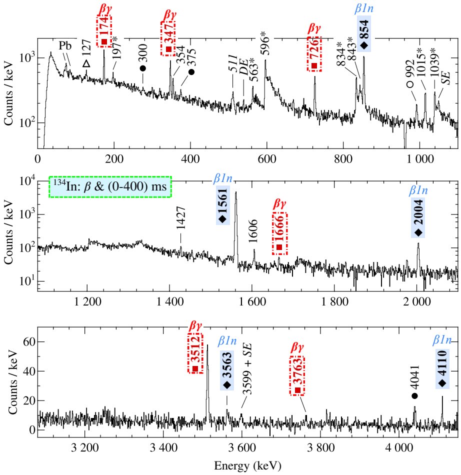


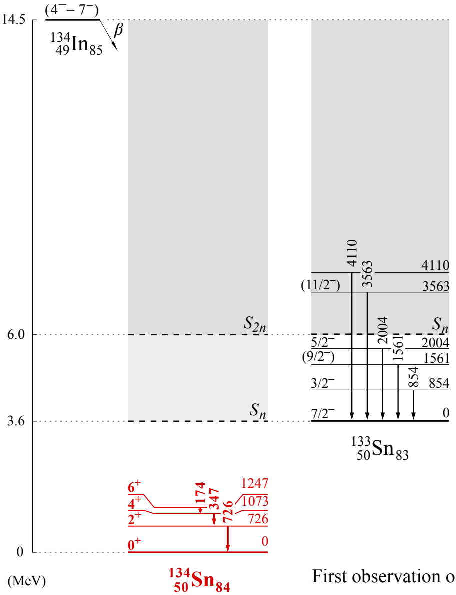
- high ℓ_n: angular momentum barrier
- small wave-function overlap
- observed following the $\beta 1n$ decay ($\beta 1n$ vs $\beta 2n$)

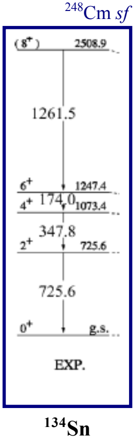
Large β-decay energy of ^{134}In



Results: $\beta\gamma$ decay of ^{134}In



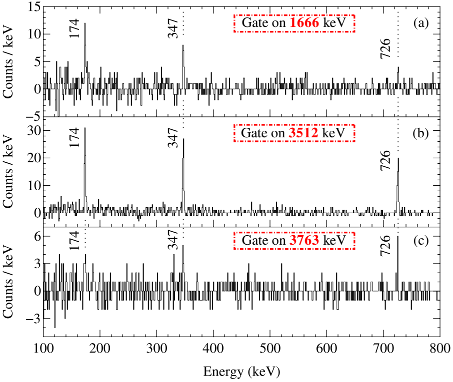


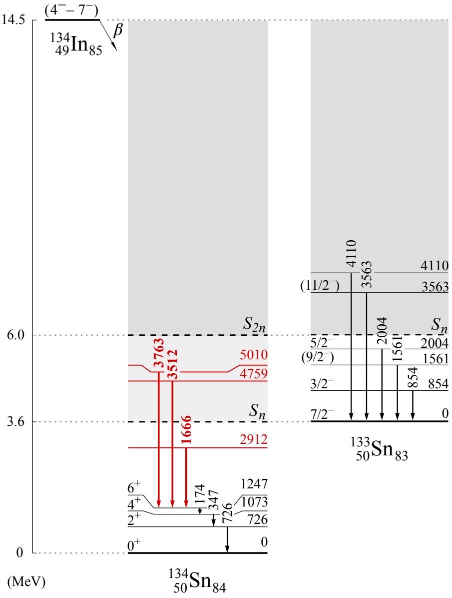


A. Korgul *et al.*,
EPJA 7, 167 (2000).

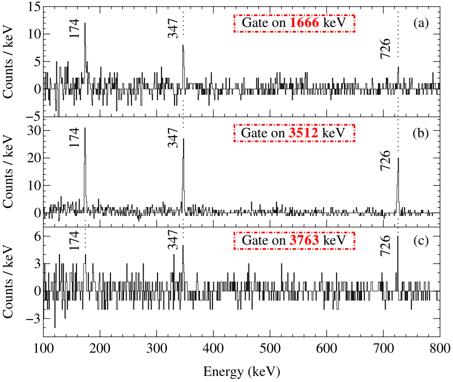
First observation of the $\beta\gamma$-decay branch

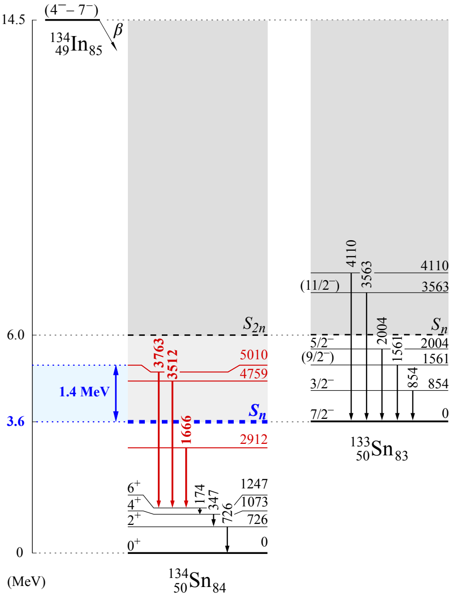
Results: new states in ^{134}Sn





Results: new states in ^{134}Sn

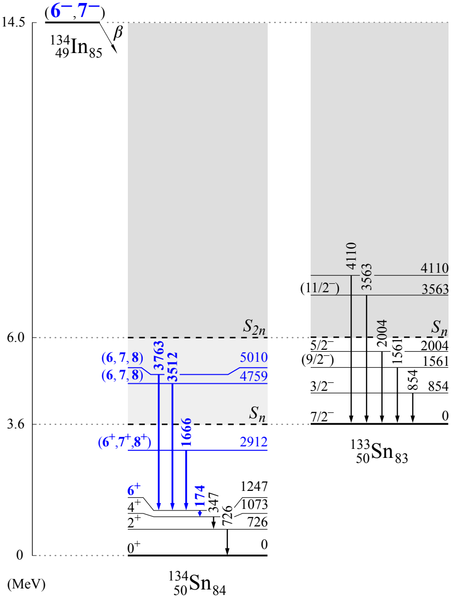




Results: new states in ^{134}Sn

	Decay branch	Daughter nucleus		Energy (keV)	Relative intensity
→	$\beta\gamma$	^{134}Sn	**6^+**	173.8(3)	4.9(3)[a]
	$\beta\gamma$	^{134}Sn	4^+	347.4(3)	4.9(3)[a]
	$\beta\gamma$	^{134}Sn	2^+	725.6(3)	4.9(4)
→	$\beta\gamma$	^{134}Sn		1665.5(3)	0.6(1)
→	$\beta\gamma$	^{134}Sn		3512.3(3)	2.7(3)
→	$\beta\gamma$	^{134}Sn		3763(1)	0.5(1)
	⋮	⋮		⋮	⋮

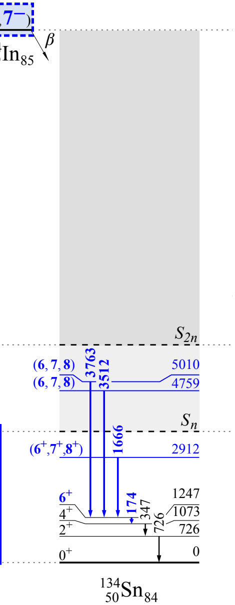
[a] Relative intensities were corrected for internal conversion α_{tot}(174 keV)= 0.227(4) and α_{tot}(347 keV)=0.0221(4) [53].

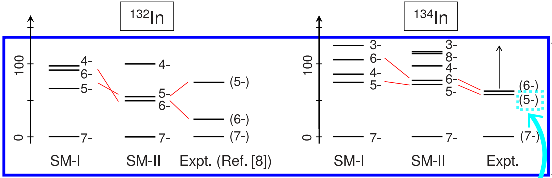


Results: ^{134}In g.s. spin and parity

	Decay branch	Daughter nucleus		Energy (keV)	Relative intensity
→	$\beta\gamma$	^{134}Sn	6^+	173.8(3)	4.9(3)^a
	$\beta\gamma$	^{134}Sn	4^+	347.4(3)	4.9(3)^a
	$\beta\gamma$	^{134}Sn	2^+	725.6(3)	4.9(4)
→	$\beta\gamma$	^{134}Sn		1665.5(3)	0.6(1)
→	$\beta\gamma$	^{134}Sn		3512.3(3)	2.7(3)
→	$\beta\gamma$	^{134}Sn		3763(1)	0.5(1)
	⋮	⋮		⋮	⋮

^{a}Relative intensities were corrected for internal conversion $\alpha_{\rm tot}$(174 keV)= 0.227(4) and $\alpha_{\rm tot}$(347 keV)=0.0221(4) [53].

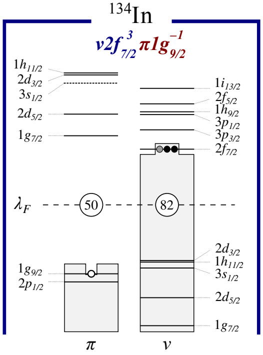


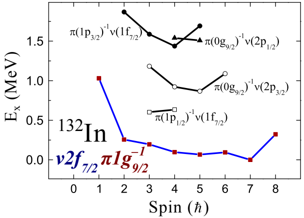


µs isomer identified

V. H. Phong, ..., M.P. *et al.*, PRC 100, 011302(R) (2019).

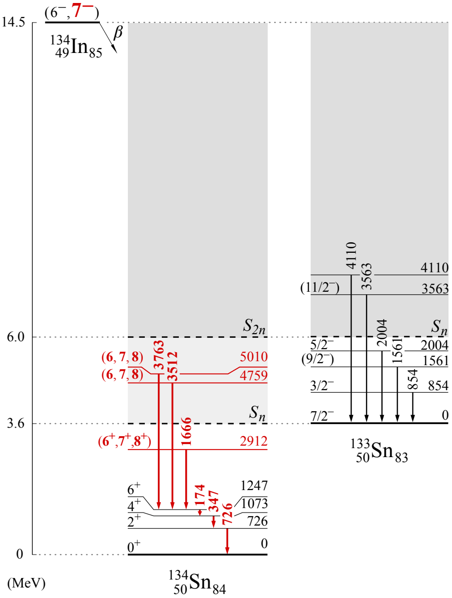
SM-I: C. Yuan *et al.* SM-II: L. Coraggio *et al.*



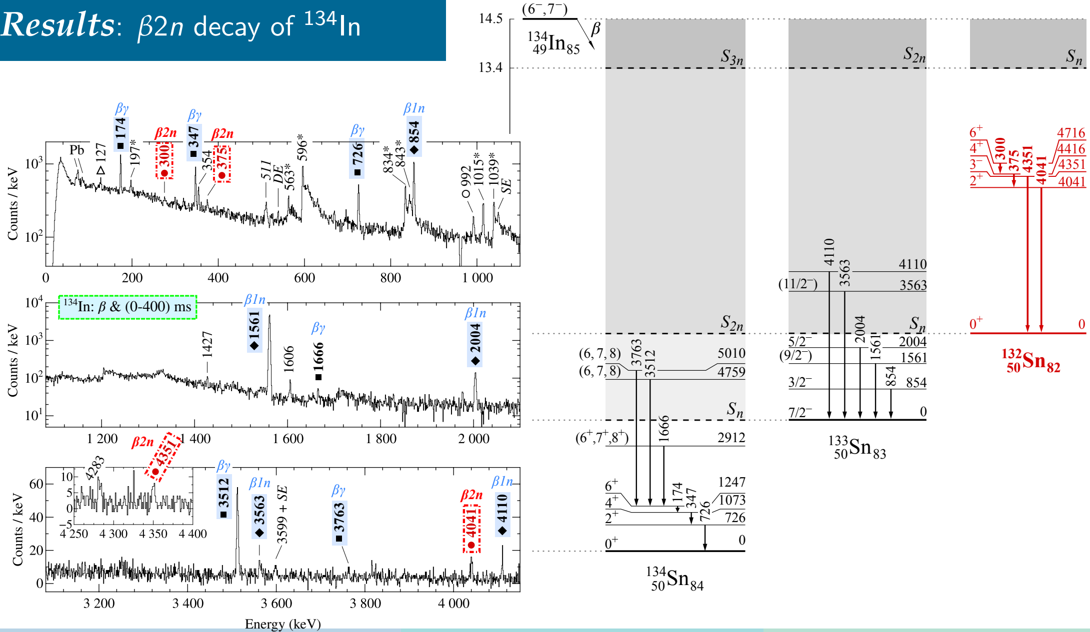


C. Yuan *et al.*, PLB 762, 237 (2016).

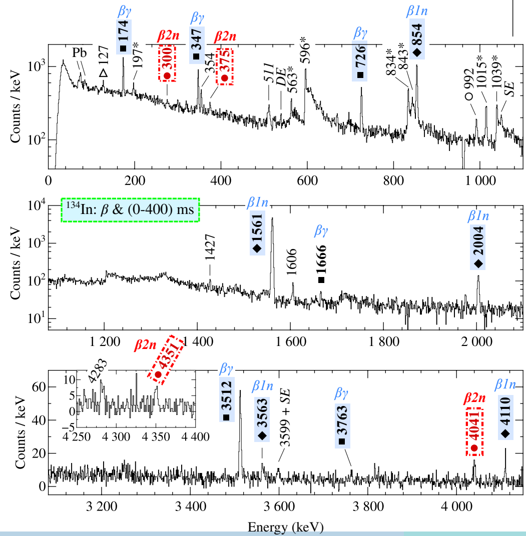
Results: $\beta\gamma$ decay of ^{134}In

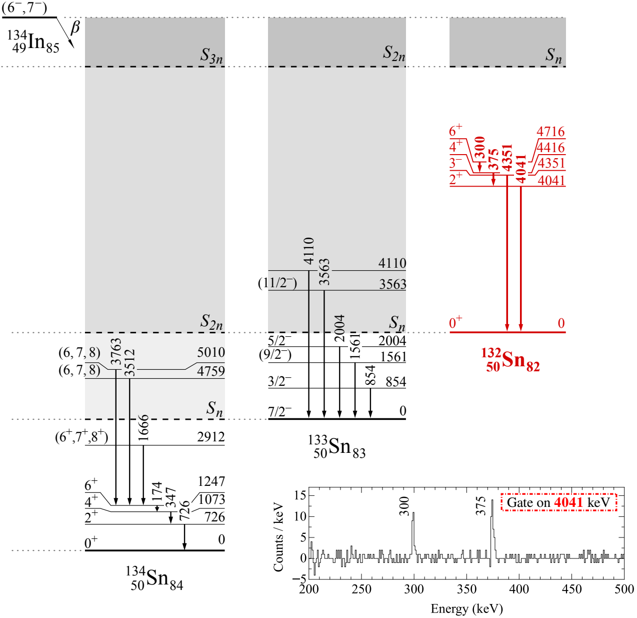


Results: $\beta 2n$ decay of ^{134}In

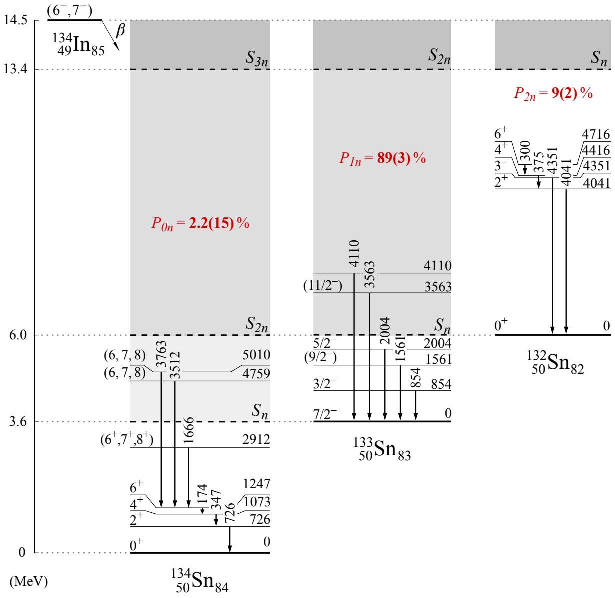


Results: $\beta 2n$ decay of ^{134}In

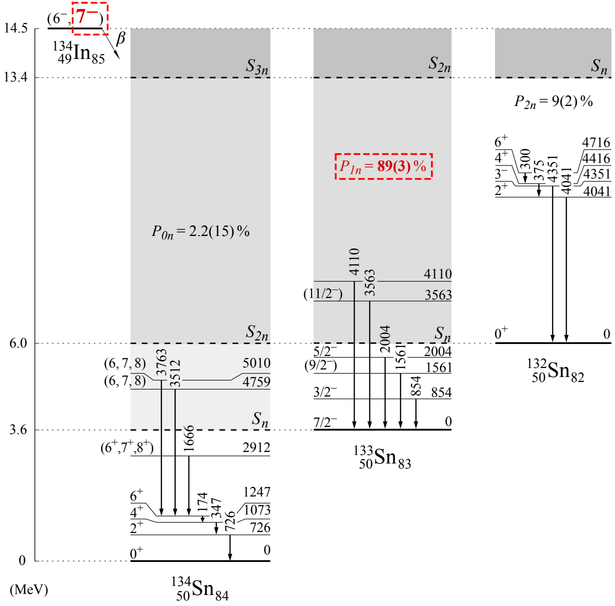




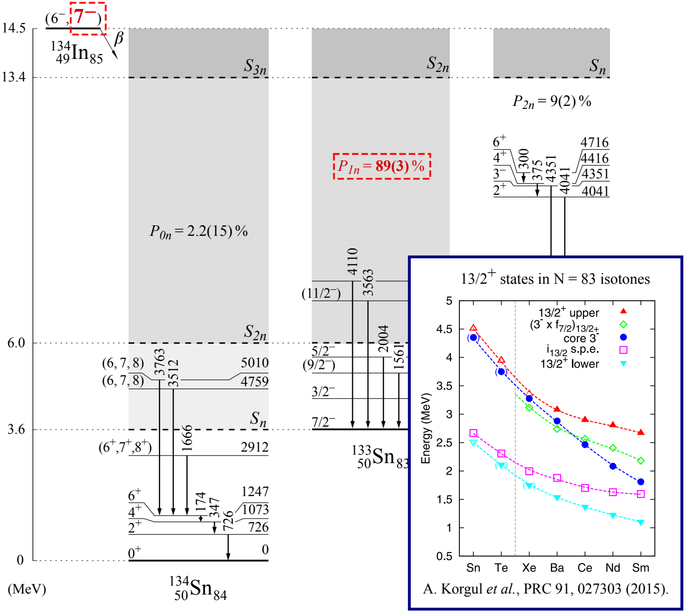
Results: β-decay branching ratios



Results: the $\nu 1i_{13/2}$ state



Results: the $\nu 1i_{13/2}$ state

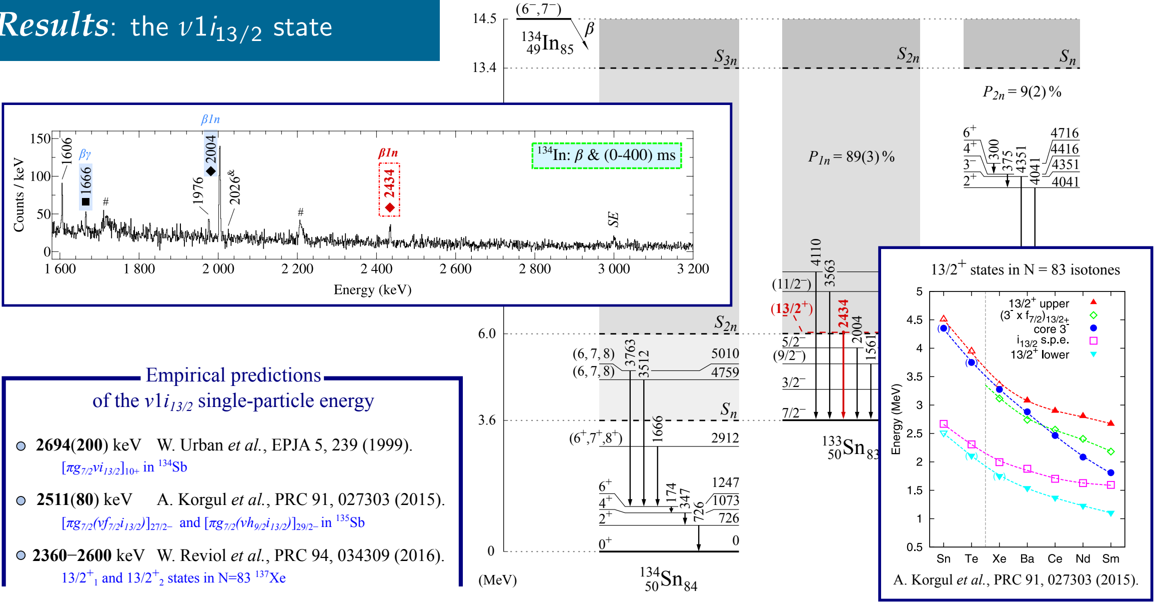


A. Korgul *et al.*, PRC 91, 027303 (2015).

Empirical predictions of the $\nu 1i_{13/2}$ single-particle energy

- **2694(200)** keV W. Urban *et al.*, EPJA 5, 239 (1999).
  $[\pi g_{7/2} \nu i_{13/2}]_{10+}$ in ^{134}Sb
- **2511(80)** keV A. Korgul *et al.*, PRC 91, 027303 (2015).
  $[\pi g_{7/2}(\nu f_{7/2} i_{13/2})]_{27/2-}$ and $[\pi g_{7/2}(\nu h_{9/2} i_{13/2})]_{29/2-}$ in ^{135}Sb
- **2360−2600** keV W. Reviol *et al.*, PRC 94, 034309 (2016).
  $13/2^+_1$ and $13/2^+_2$ states in N=83 ^{137}Xe

Results: the $\nu 1i_{13/2}$ state



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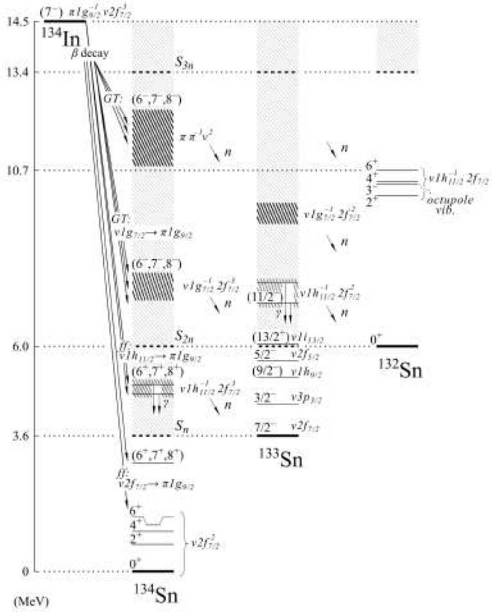
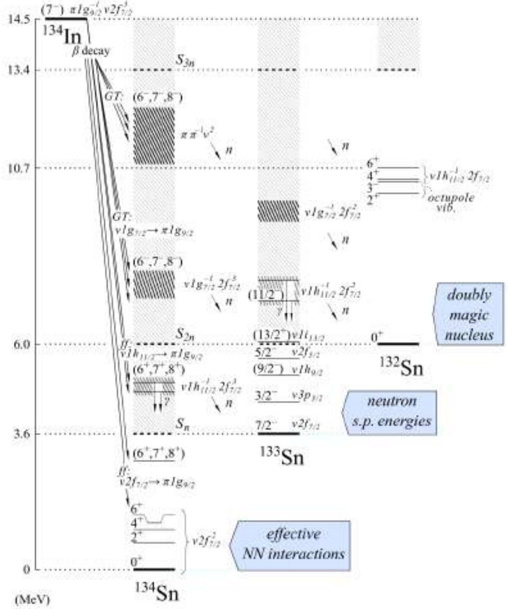
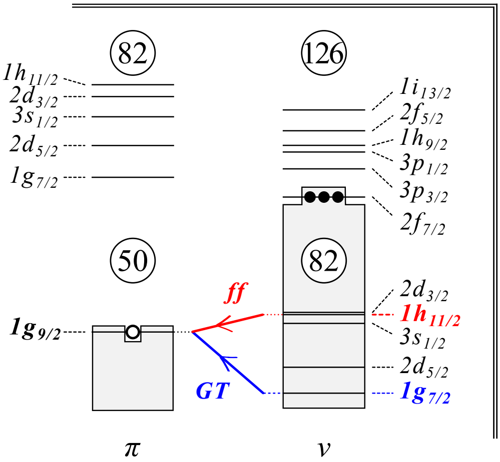
Discussion: *GT* and *ff* decays of ^{134}In

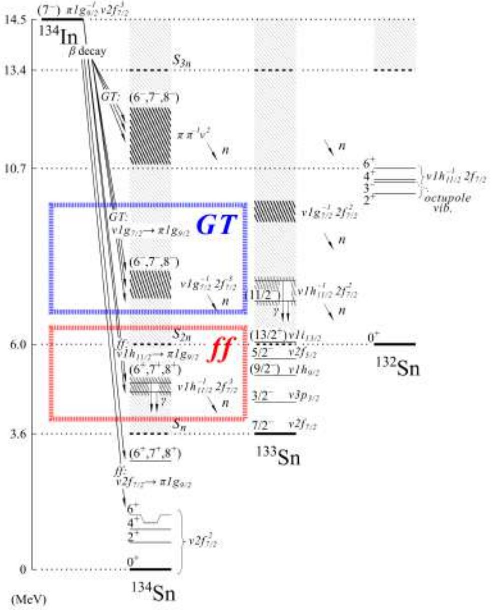


Discussion: *GT* and *ff* decays of ^{134}In

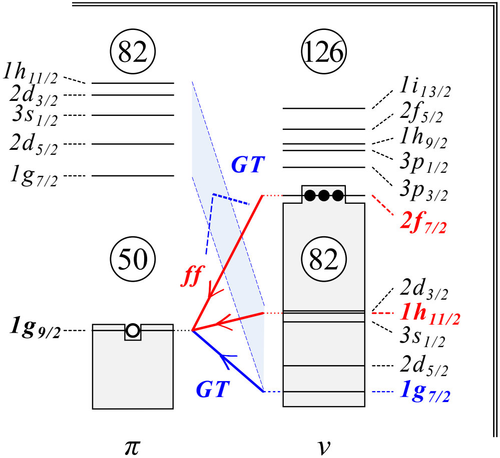


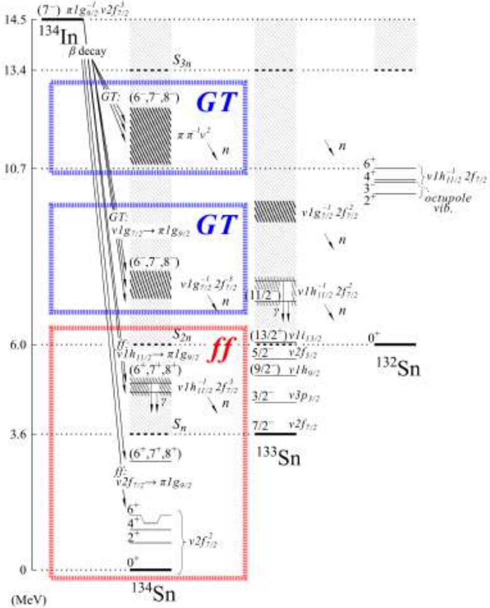
Discussion: *GT* and *ff* decays of ^{134}In



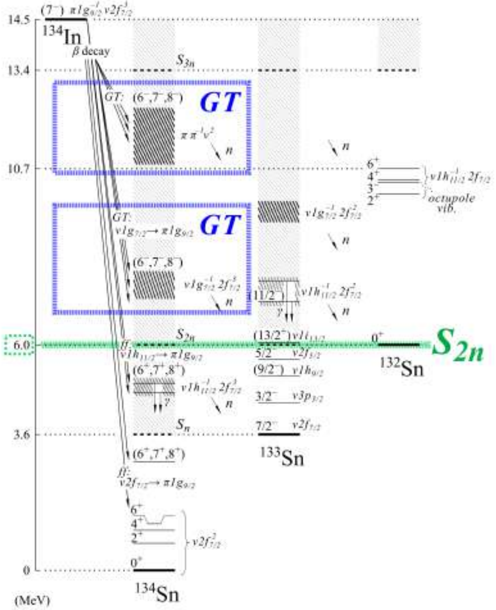


Discussion: *GT* and *ff* decays of ^{134}In



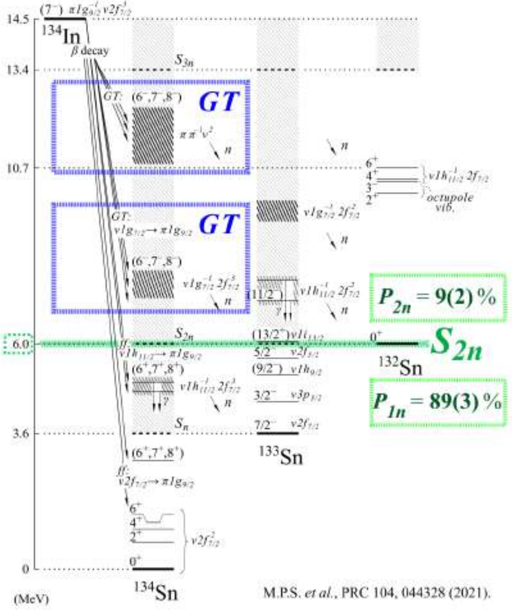


Discussion: *GT* and *ff* decays of ^{134}In



Discussion: Predictions for $P_{1n/2n}$ of ^{134}In

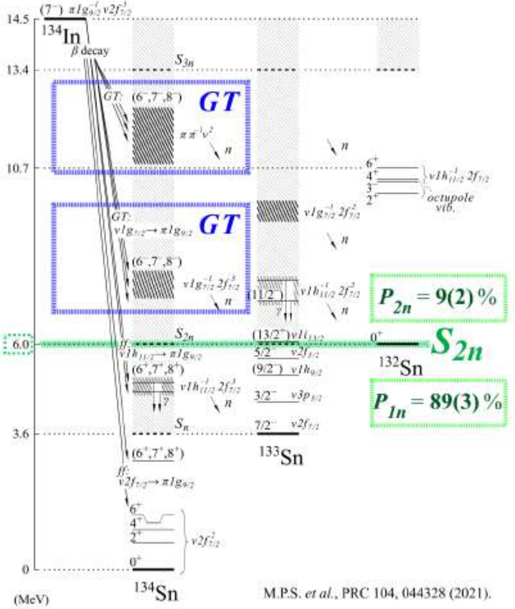
Method	P_{1n} (%)	P_{2n} (%)
QRPA-1	0.60	99.4
QRPA-2	6.5	86.7
QRPA + HF	78	15
RHB + RQRPA	18.9	46.8
EDM	64.5	2.2
$\text{EDM}_{\text{cutoff}}$	28	39
Experiment	89(3)	9(2)



M.P.S. *et al.*, PRC 104, 044328 (2021).

Discussion: Predictions for $P_{1n/2n}$ of ^{134}In

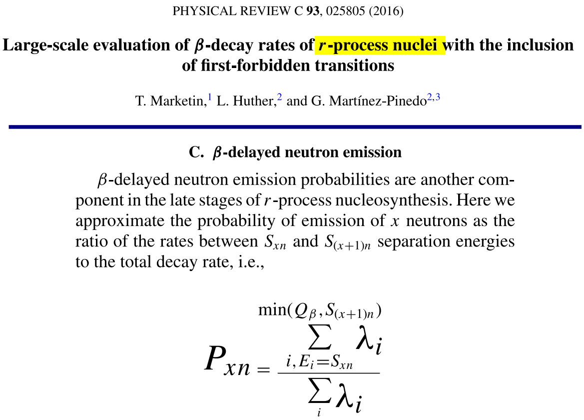
Method	P_{1n} (%)	P_{2n} (%)	
QRPA-1	0.60	99.4	*GT only* + ***cutoff***
QRPA-2	6.5	86.7	*GT* + *ff* + ***cutoff***
QRPA + HF	78	15	*GT* + *ff* + ***n*** vs. γ
RHB + RQRPA	18.9	46.8	*GT* + *ff* + ***cutoff***
EDM	64.5	2.2	*GT* + *ff* + ***n*** vs. γ
EDM$_{\text{cutoff}}$	28	39	*GT* + *ff* + ***cutoff***
Experiment	89(3)	9(2)	



M.P.S. *et al.*, PRC 104, 044328 (2021).

Discussion: Predictions for $P_{1n/2n}$ of ^{134}In

"Cutoff" method



PHYSICAL REVIEW C **93**, 025805 (2016)

Large-scale evaluation of β-decay rates of *r*-process nuclei with the inclusion of first-forbidden transitions

T. Marketin,[1] L. Huther,[2] and G. Martínez-Pinedo[2,3]

C. β-delayed neutron emission

β-delayed neutron emission probabilities are another component in the late stages of r-process nucleosynthesis. Here we approximate the probability of emission of x neutrons as the ratio of the rates between S_{xn} and $S_{(x+1)n}$ separation energies to the total decay rate, i.e.,

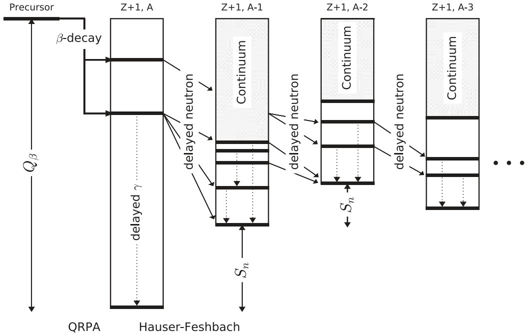
$$P_{xn} = \frac{\displaystyle\sum_{i,E_i=S_{xn}}^{\min(Q_\beta,S_{(x+1)n})} \lambda_i}{\displaystyle\sum_i \lambda_i}$$

Combined QRPA+HF approach

PHYSICAL REVIEW C **94**, 064317 (2016)

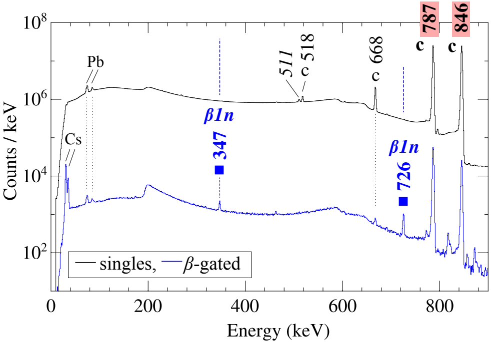
Neutron-γ competition for β-delayed neutron emission

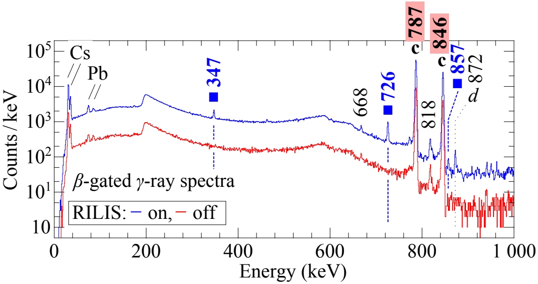
M. R. Mumpower,* T. Kawano, and P. Möller

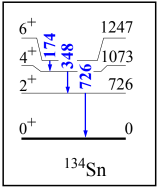


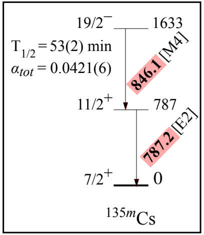
Results: β decay of ^{135}In

Severe contamination of the A = 135 beam

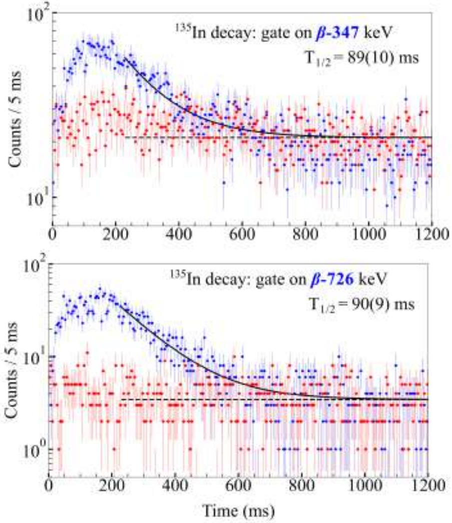


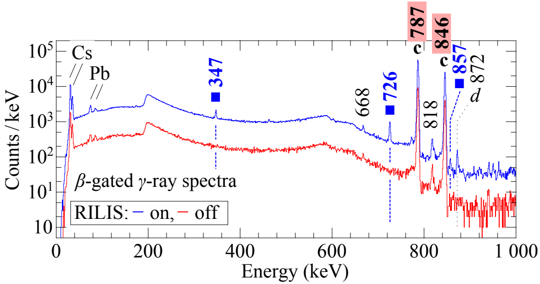






Results: β decay of ^{135}In

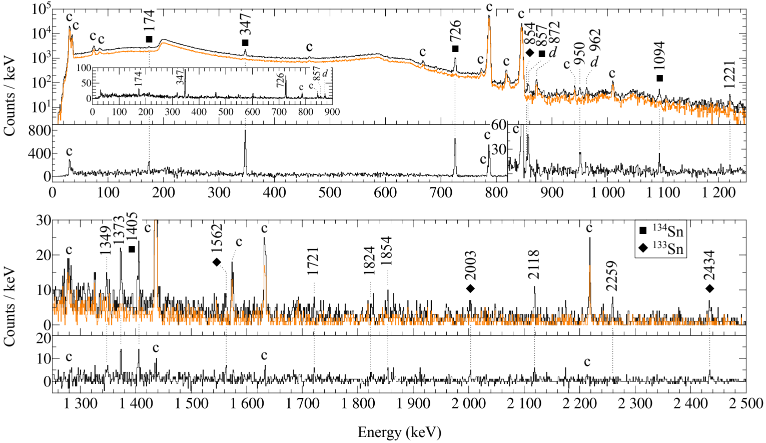




$T_{1/2}$ = 89(7) ms	ISOLDE (2021) M.P.S. *et al.*, PRC 104, 044328 (2021).
$T_{1/2}$ = 92(10) ms	ISOLDE (2002) I. Dillmann *et al.*, EPJA 13, 281 (2002).
$T_{1/2}$ = 103(5) ms	RIKEN (2015) G. Lorusso *et al.*, PRL 114, 192501 (2015).

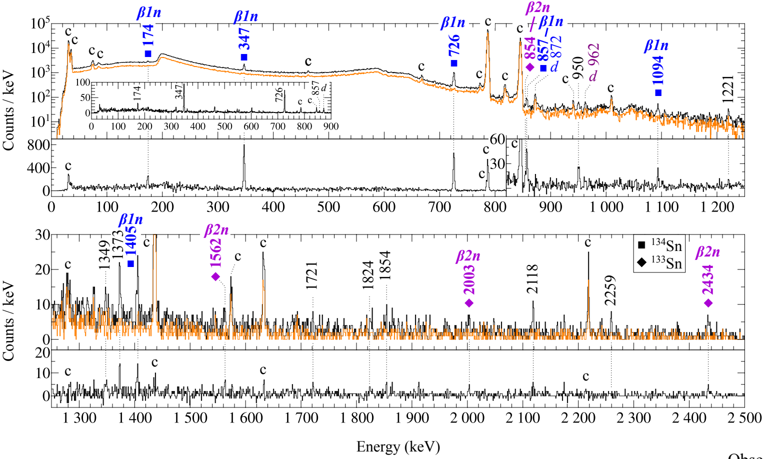
Results: β decay of ^{135}In

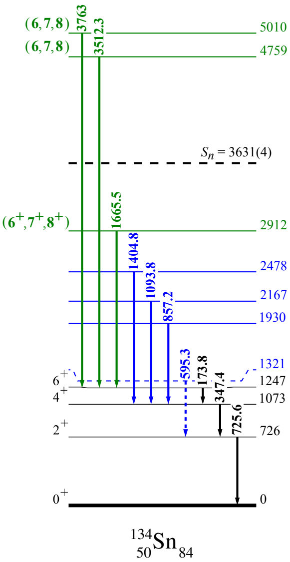
Top panels: ▬ t > 600 ms, ▬ no gate   Bottom panels: t < 400 ms, long-lived background subtracted



Results: β decay of ^{135}In

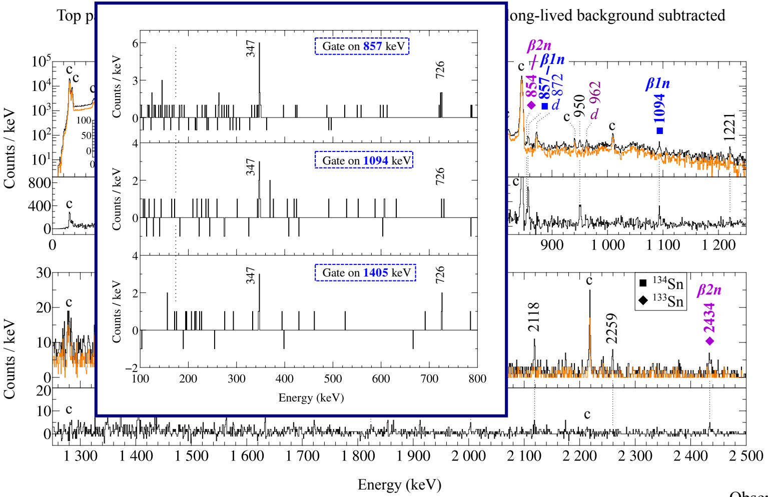
Top panels: ▬ t > 600 ms, ▬ no gate Bottom panels: t < 400 ms, long-lived background subtracted

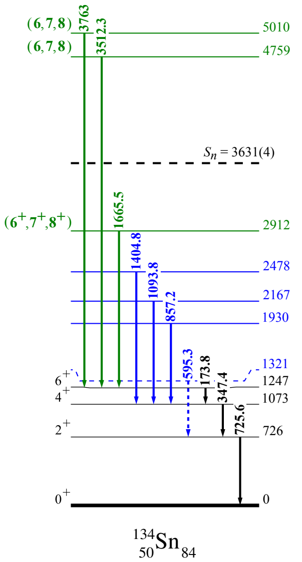




Observed in the β decay of: **^{134}In**, **^{135}In**, or ^{134,135}In

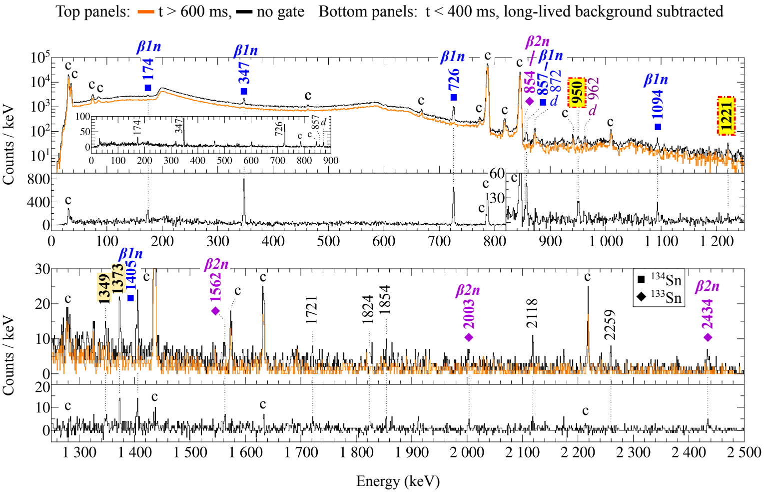
Results: β decay of ^{135}In



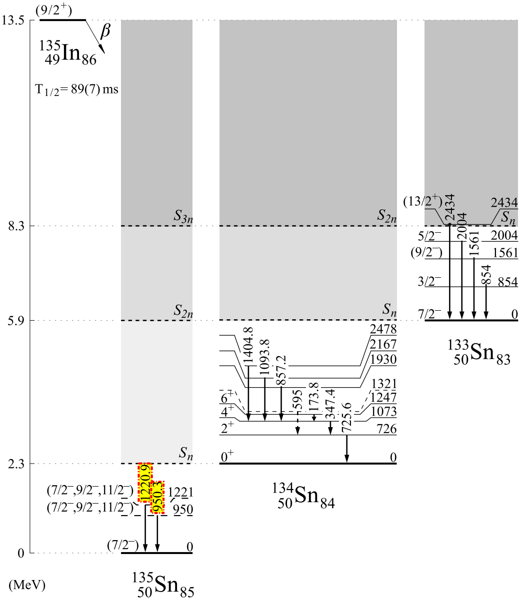


Observed in the β decay of: **^{134}In**, **^{135}In**, or ^{134,135}In

Results: β decay of ^{135}In



Results: decay scheme of ^{135}In



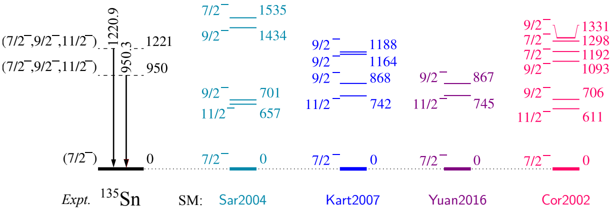
Shell-model predictions: ^{135}Sn

Sar2004
S.and M.Sarkar, EPJA 21, 61 (2004).

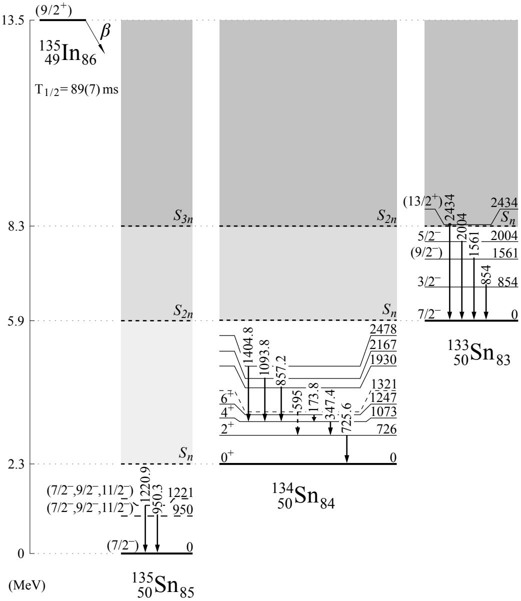
Kart2007
M. P. Kartamyshev *et al.*, PRC 76, 024313 (2007).

Yuan2016
C. Yuan *et al.*, PLB 762, 237 (2016).

Cor2002
L. Coraggio *et al.*, PRC 65, 051306(R) (2002).



M.P.S. *et al.*, PRC 104, 044328 (2021).



Shell-model predictions: ^{134}Sn

neutron core excitations considered

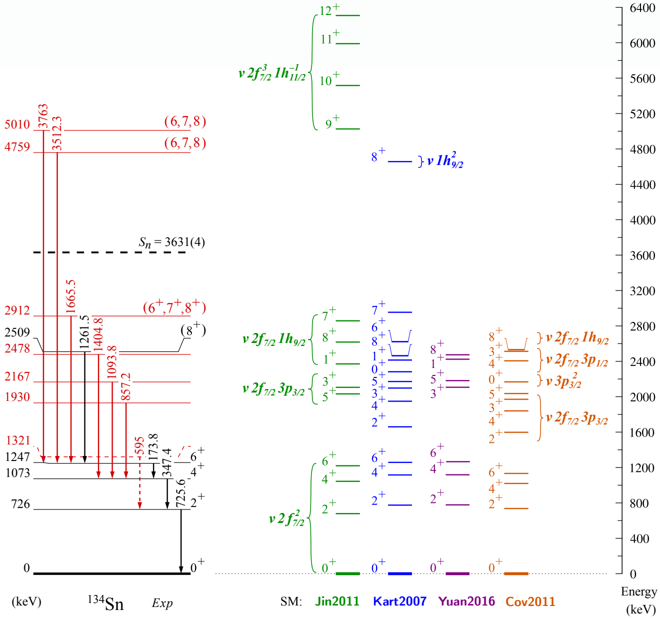
ν $1i_{13/2}$ not included

Jin2011
H. Jin *et al.*, PRC 84, 044324 (2011).

Kart2007
M. P. Kartamyshev *et al.*, PRC 76, 024313 (2007).

Yuan2016
C. Yuan *et al.*, PLB 762, 237 (2016).

Cov2011
A. Covello *et al.*, JPConf.Ser. 267, 012019 (2011).



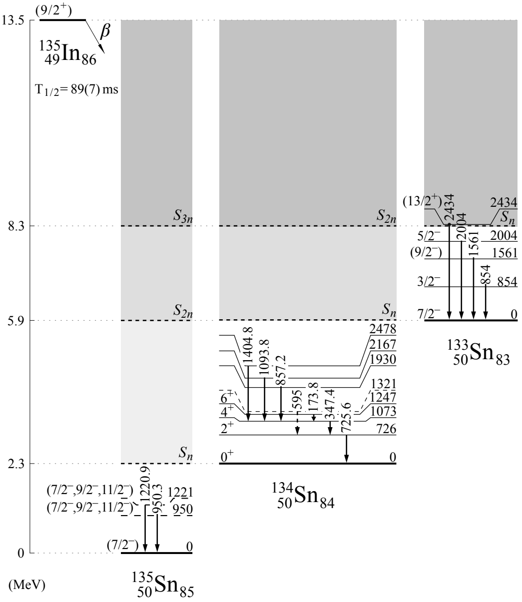
Expt.
M.P.S. *et al.*, PRC 104, 044328 (2021).

Discussion: βn-decay branching ratios

	Nucleus	^{133}In		^{135}In	
	Method	P_{1n}	P_{2n}	P_{1n}	P_{2n}
GT only + ***cutoff***	QRPA-1	99.6	0.4	86.2	8.3
GT + *ff* + ***cutoff***	QRPA-2	92.7	0.2	23.5	64.3
GT + *ff* + ***n* vs. *γ***	QRPA+HF	93	0	86	10
GT + *ff* + ***cutoff***	RHB+RQRPA	67.2	0.4	49	41.2
GT + *ff* + ***n* vs. *γ***	EDM	84.3	0	52.4	1.2
GT + *ff* + ***cutoff***	EDM$_{cutoff}$	–	–	–	–
	Experiment:	90(3)	–	–	–

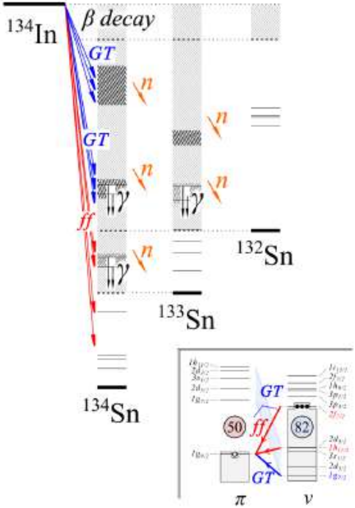
Decay branch	Daughter nucleus	Energy (keV)	Relative intensity
$\beta\gamma$[a]	^{135}Sn	950.3(3)	7(1)
$\beta\gamma$[a]	^{135}Sn	1220.9(3)	4.0(9)
$\beta 1n$	^{134}Sn	173.8(3)	25(5)[b]
$\beta 1n$	^{134}Sn	347.4(3)	74(5)[b]
$\beta 1n$[a]	^{134}Sn	595(1)[c]	11(5)[d]
$\beta 1n$	^{134}Sn	725.6(3)	100(6)
$\beta 1n$	^{134}Sn	857.2(3)	7(1)
$\beta 1n$	^{134}Sn	1093.8(6)	6(1)
$\beta 1n$	^{134}Sn	1404.8(6)	3.9(8)
$\beta 2n$	^{133}Sn	854.0(8)	1.6(9)
$\beta 2n$	^{133}Sn	1562.4(8)	2.0(6)
$\beta 2n$	^{133}Sn	2003.3(8)	1.8(6)
$\beta 2n$[e]	^{133}Sn	2434.2(7)	2.6(7)

Transition intensities suggest that the *β1n*-decay branch dominates



Summary

- β decays of ^{134,135}In provide unique conditions for the simultaneous investigation of **one**- and **two-neutron excitations** as well as states formed by couplings of valence neutrons to **excitations of the ^{132}Sn core**.
- The $\beta\gamma$- and $\beta 2n$-decay branches of ^{134}In have been **observed for the first time**.
- Although the prevalent $\nu 1g_{7/2} \rightarrow \pi 1g_{9/2}$ GT transition feeds neutron-unbound states at excitation **energies exceeding S_{2n}** of ^{134}Sn, the ^{134}In β decay is **dominated by $\beta 1n$** emission.
- A significant contribution of **γ-ray emission** from **neutron-unbound states** populated in ^{133}Sn and ^{134}Sn was observed.
- Candidate for a γ ray depopulating the **missing $\nu 1i_{13/2}$ s. p. state** in ^{133}Sn was observed.
- Transitions following the β decay of ^{135}In were **identified for the first time**.



Outlook

Completed

Neutron spectroscopy

^{133,133m}**In** β decay

M. Madurga *et al.*

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Neutron unbound single particle states in ^{133}Sn from the beta decay of ^{133}In

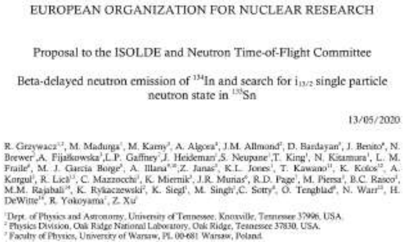
7/10/2016

Accepted

Neutron spectroscopy

^{134}**In** β decay

R. Grzywacz,
M. Karny *et al.*



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Beta-delayed neutron emission of ^{134}In and search for $i_{13/2}$ single particle neutron state in ^{133}Sn

13/05/2020

R. Grzywacz, M. Madurga, M. Karny, A. Algora, J.M. Allmond, D. Bardayan, J. Benito, N. Brewer, A. Fijałkowska, L.P. Gaffney, J. Heideman, S. Neupane, T. King, N. Kitamura, L. M. Fraile, M. J. Garcia Borge, A. Illana, Z. Janas, K.L. Jones, T. Kawano, K. Kolos, A. Korgul, R. Lică, C. Mazzocchi, K. Miernik, J.R. Murias, R.D. Page, M. Piersa, B.C. Rasco, M.M. Rajabali, K. Rykaczewski, K. Siegl, M. Singh, C. Sotty, O. Tengblad, N. Warr, H. DeWitte, R. Yokoyama, Z. Xu

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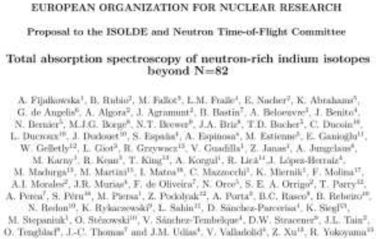
Accepted

Total absorption spectroscopy

$^{132\text{–}134}$**In** β decay

A. Fijałkowska *et al.*



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

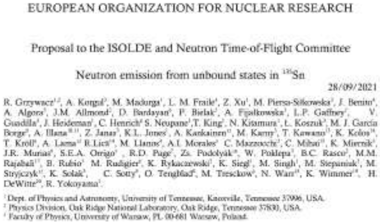
Total absorption spectroscopy of neutron-rich indium isotopes beyond N=82

Under review

Neutron spectroscopy

^{135}**In** β decay

R. Grzywacz,
A. Korgul *et al.*



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Proposal to the ISOLDE and Neutron Time-of-Flight Committee

Neutron emission from unbound states in ^{135}Sn

28/09/2021

R. Grzywacz, A. Korgul, M. Madurga, L. M. Fraile, Z. Xu, M. Piersa-Siłkowska, J. Benito, A. Algora, J.M. Allmond, D. Bardayan, P. Bielak, A. Fijałkowska, L.P. Gaffney, V. Guadilla, J. Heideman, C. Henrich S. Neupane, T. King, N. Kitamura, L. Koszuk, M. J. Garcia Borge, A. Illana, Z. Janas, K.L. Jones, A. Kankainen, M. Karny, T. Kawano, K. Kolos, T. Kröll, A. Lama R.Lică, M. Llanos, A.I. Morales C. Mazzocchi, C. Mihai, K. Miernik, J.R. Murias, S.E.A. Orrigo, R.D. Page, Zs. Podolyák, W. Poklepa, B.C. Rasco, M.M. Rajabali, B. Rubio M. Rudigier, K. Rykaczewski, K. Siegl, M. Singh, M. Stepaniuk, M. Stryjczyk, K. Solak, C. Sotty, O. Tengblad, M. Tresckow, N. Warr, K. Wimmer, H. DeWitte, R. Yokoyama.

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First β-decay spectroscopy of ^{135}In and new β-decay branches of ^{134}In

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