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Ground state spin of ^{101}Sn and the role of the tensor force in exotic nuclei

Joochun (Jason) Park
TRIUMF/UBC

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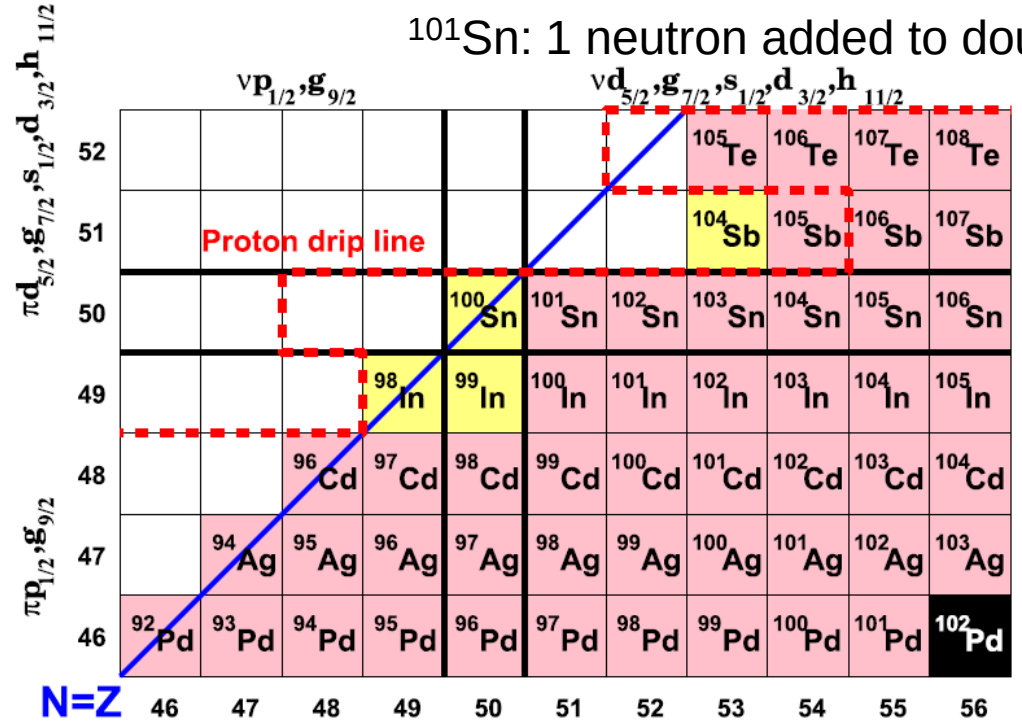
Introduction: why ^{101}Sn?

^{101}Sn: 1 neutron added to doubly-magic ^{100}Sn core



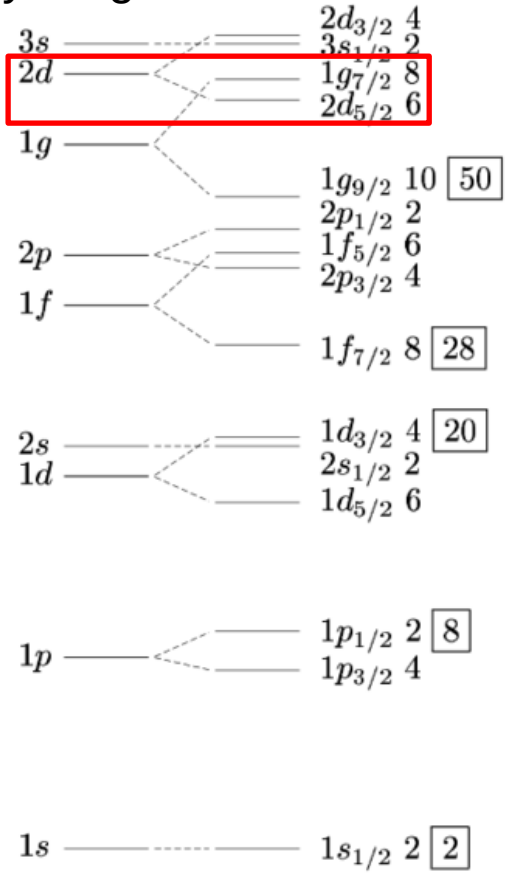
Nucleus produced with known half-life

Nucleus with known excited states

Stable nucleus

T. Faestermann, M. Górska, and H. Grawe, Prog. Part. Nucl. Phys. 69, 85 (2013)

C. B. Hinke et al., Nature 486, 341 (2012)



Krane, *Introductory Nuclear Physics* (1988)

Ground state spin of ^{101}Sn: $5/2^+$ or $7/2^+$?

Robustness of the shell model with isotopes far away from stability

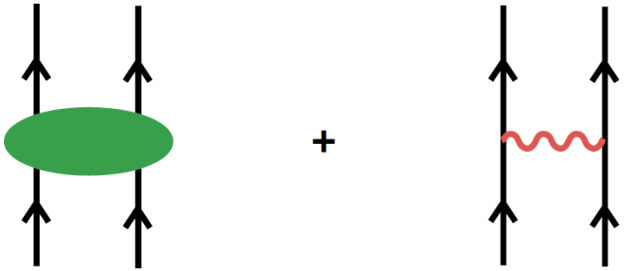
Introduction: two-body tensor force in exotic nuclei

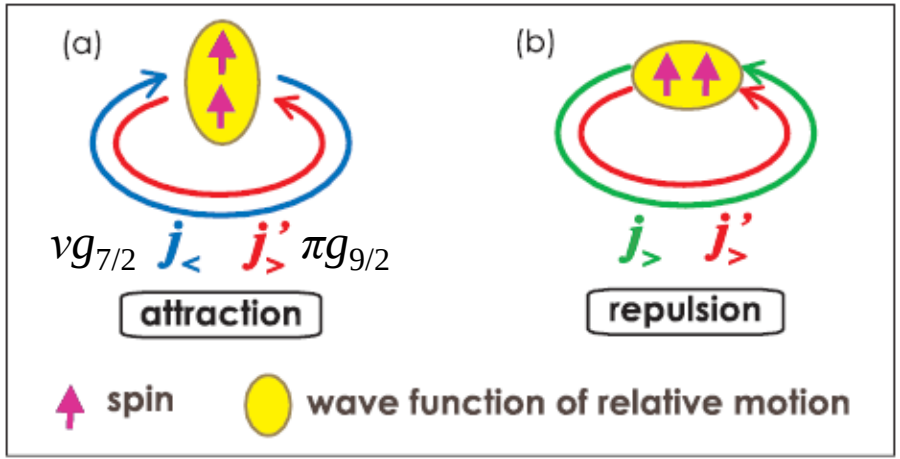
T. Otsuka et al., PRL 95, 232502 (2005) and T. Otsuka et al., PRL 104, 012501 (2010)

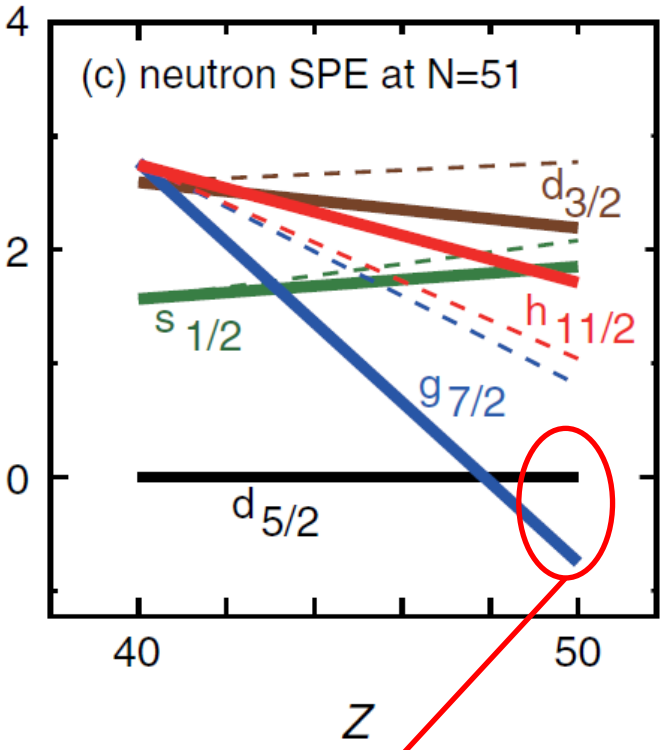
(a) central force : Gaussian (strongly renormalized)

(b) tensor force : π + ρ meson exchange

V_{MU} =



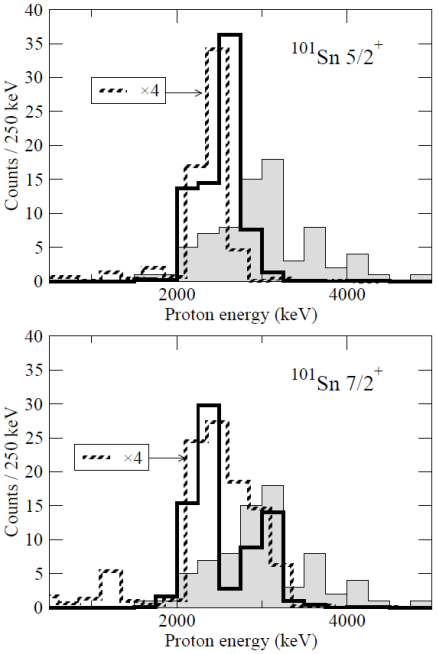


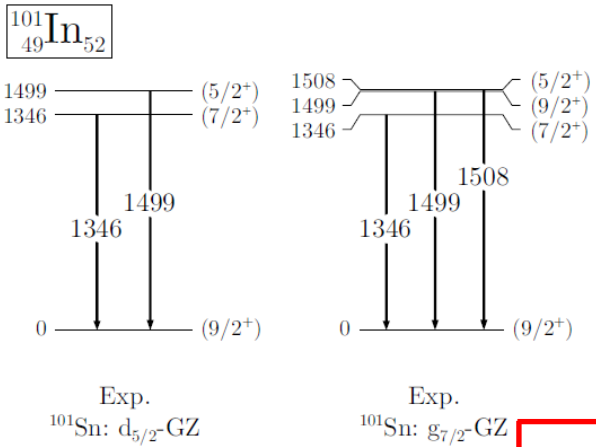


$J^\pi = 7/2^+$ if sufficient tensor force is manifest in ^{101}Sn

Introduction: literature on ^{101}Sn's ground state spin

β-γ, βp decay spectroscopy of ^{101}Sn





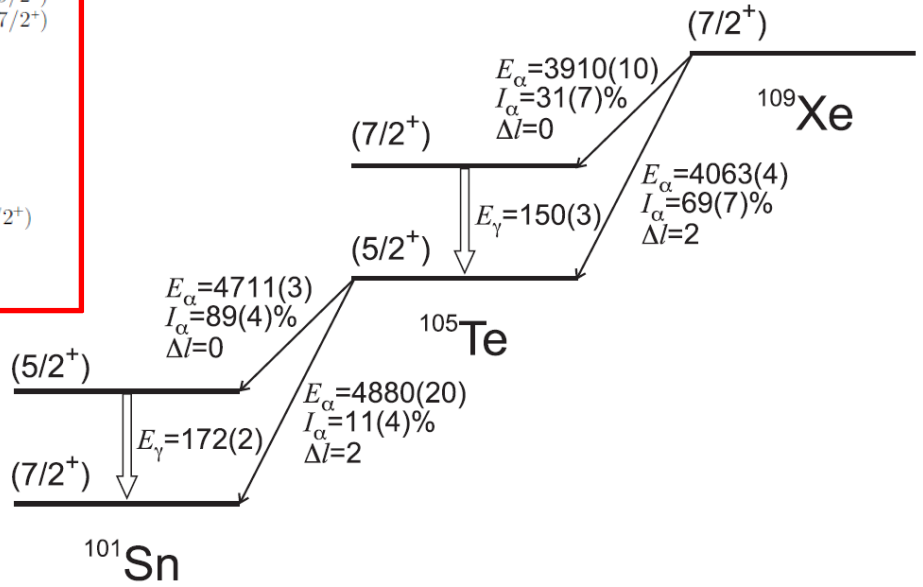
K. Straub, PhD thesis, TU Munich (2010)

Inconclusive from these studies

O. Kavatsyuk et al., EPJ A 31, 319 (2007)

γ-βp: **5/2$^+$** with $E(7/2^+) - E(5/2^+)$ = 172-keV
[D. Seweryniak et al., PRL 99, 022504 (2007)]

α-γ decay spectroscopy of ^{109}Xe → ^{105}Te → ^{101}Sn chain



I. G. Darby et al., PRL 105, 162502 (2010): **7/2$^+$**
S. N. Liddick et al., PRL 97, 082501 (2006): **5/2$^+$**

Method: isotope production & identification

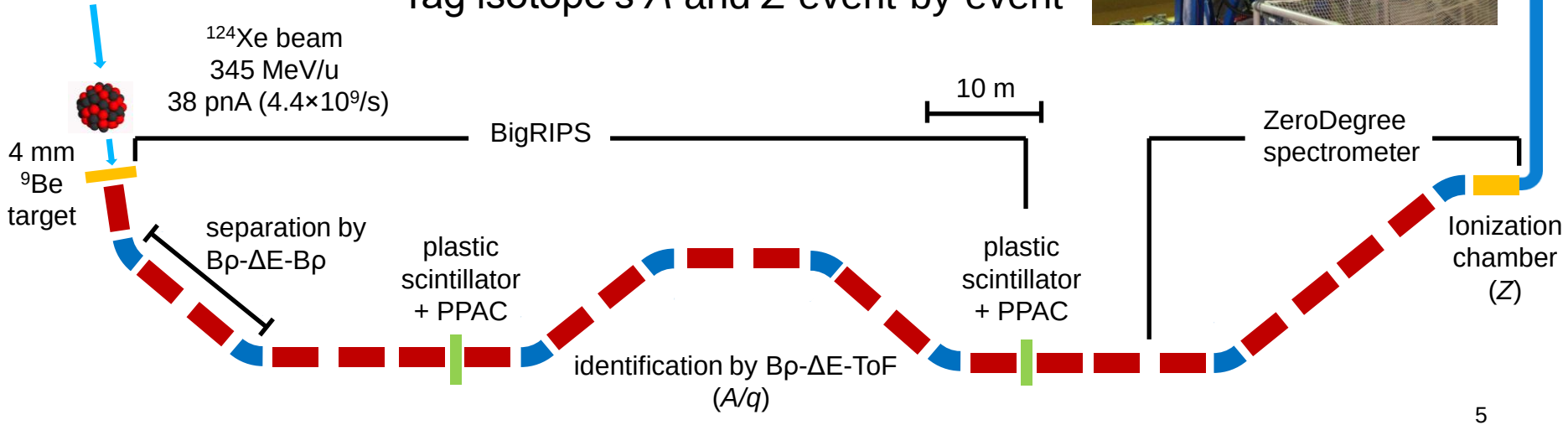
RIKEN SRC

Fragmentation reaction

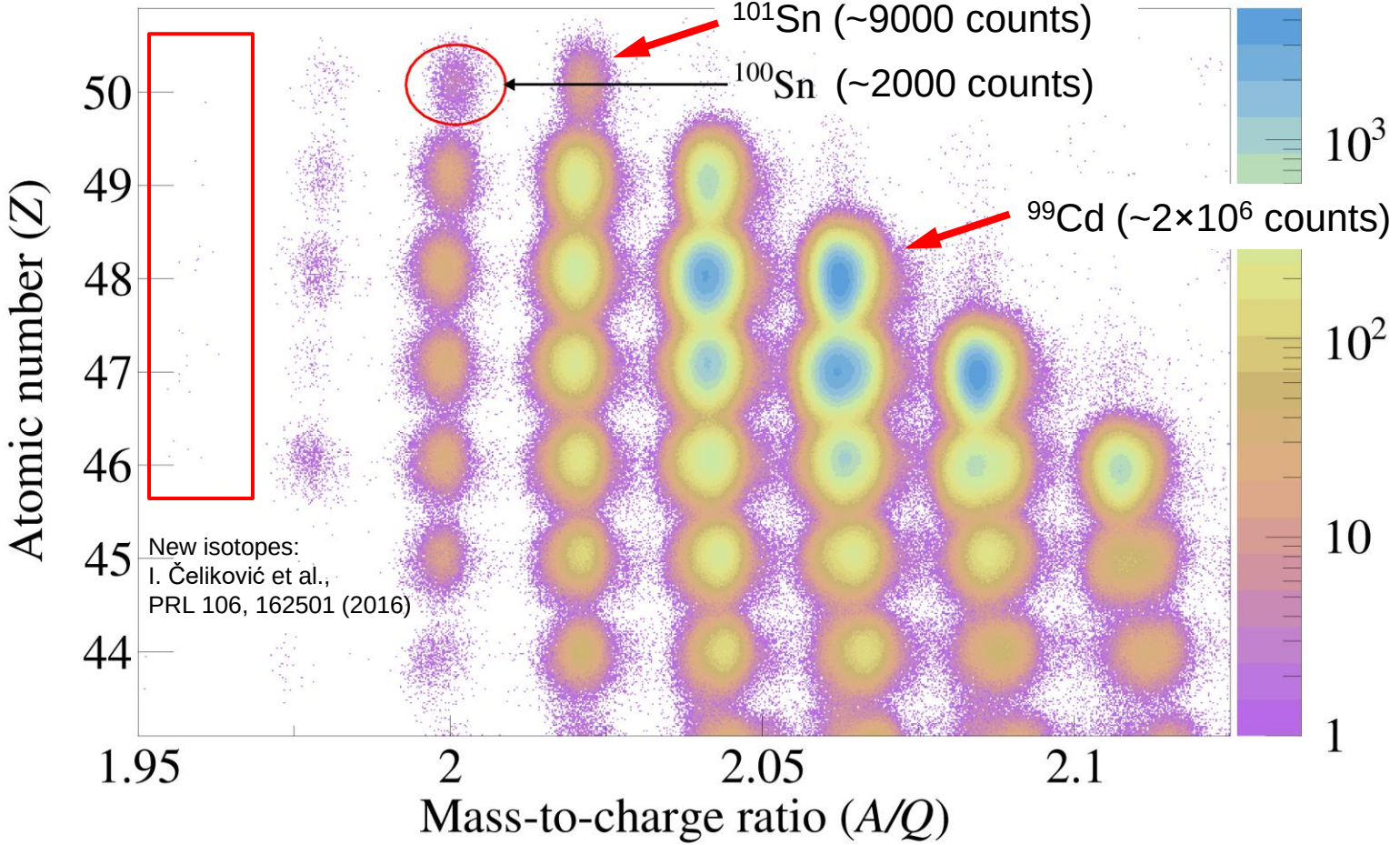
$$^{124}\mathrm{Xe} + {}^{9}\mathrm{Be} \rightarrow \begin{cases} {}^{101}\mathrm{Sn} + \ldots \\ {}^{100}\mathrm{Sn} + \ldots \\ \ldots \end{cases}$$

Tag isotope's *A* and *Z* event-by-event

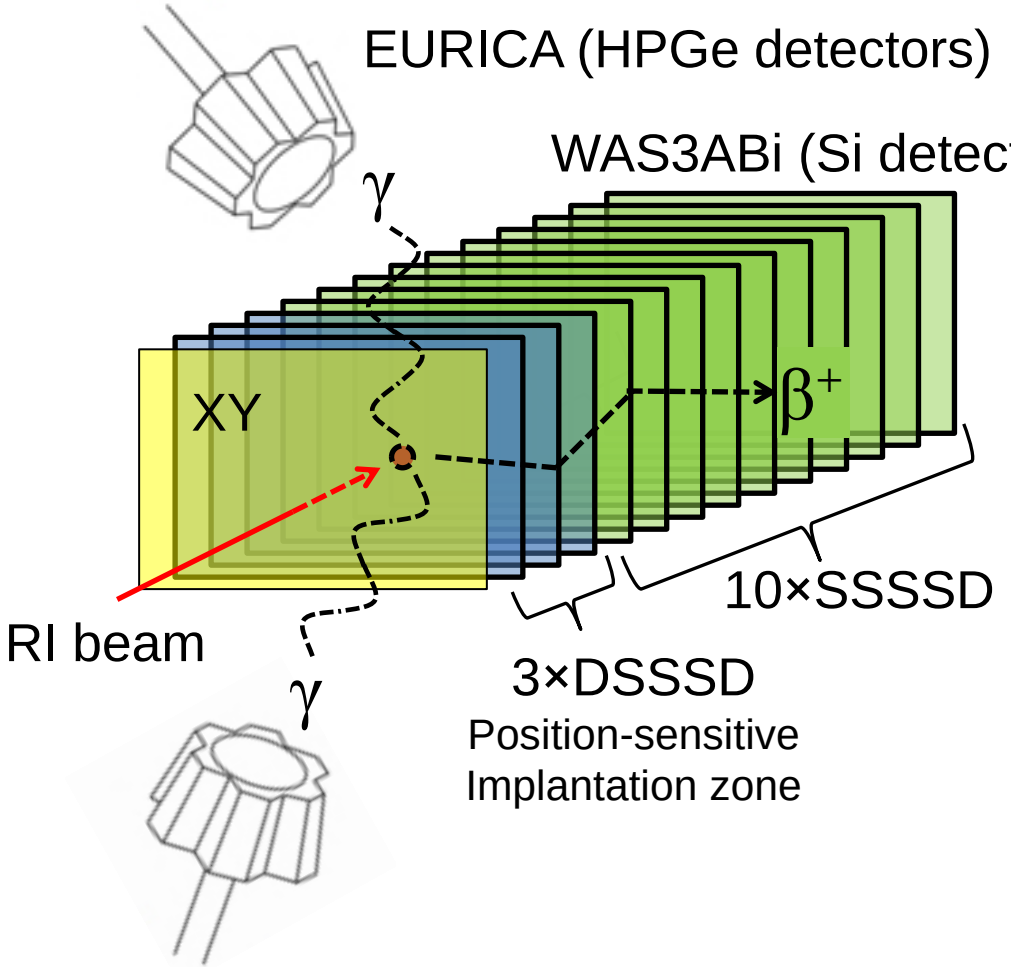
EURICA + WAS3ABi

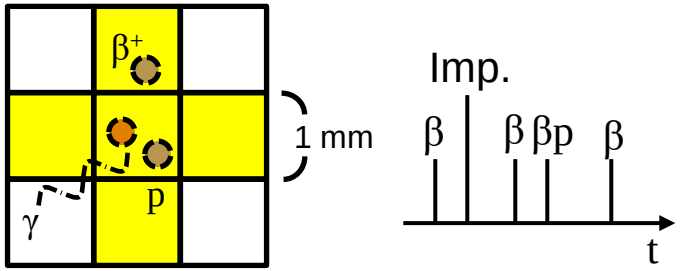


Results: isotope production (8.5 days of beam)

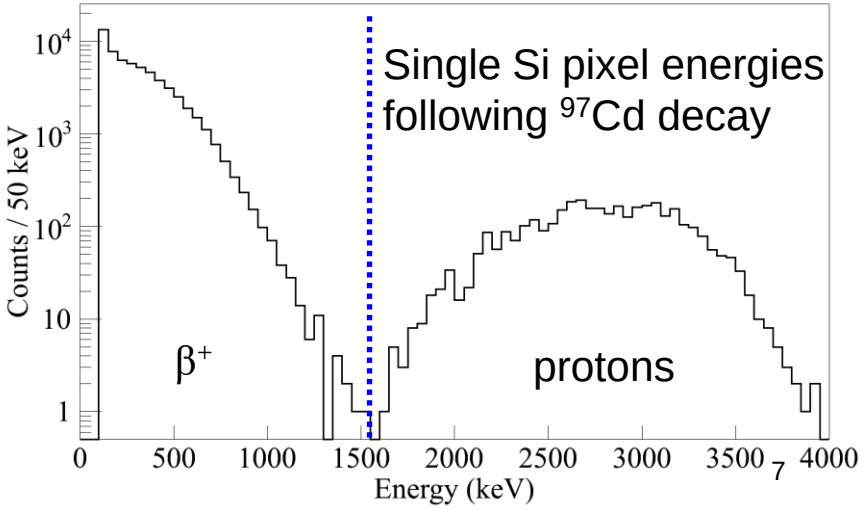


Method: decay spectroscopy



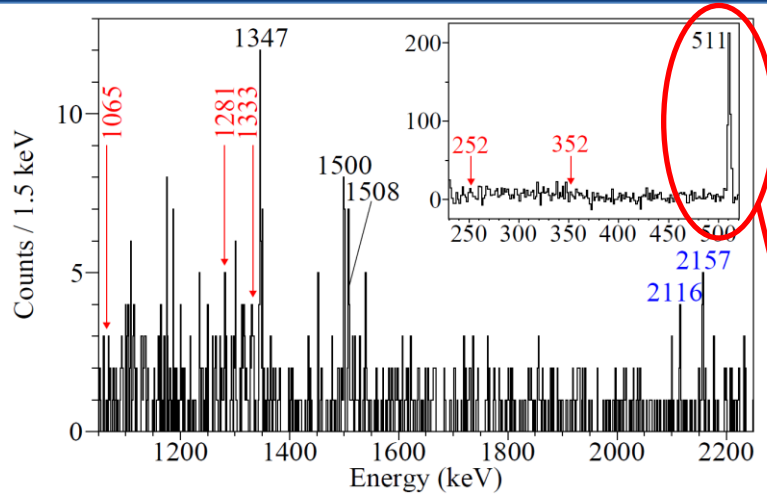


Correlate β^+/p to imp. events in spatial/time window, measure γ-rays emitted from daughter nuclei

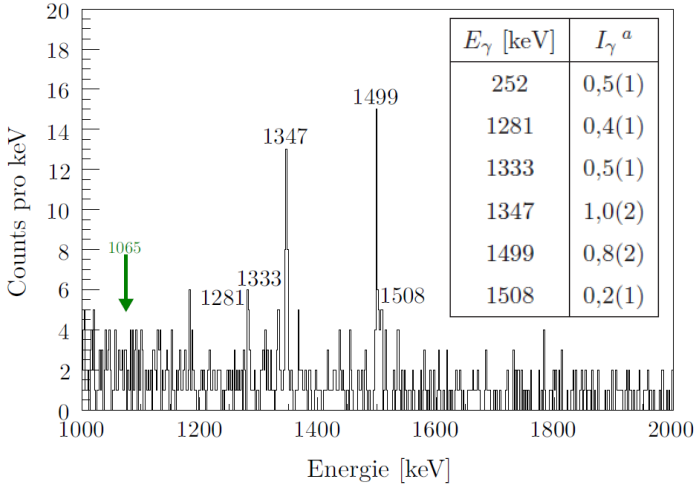


Results: β-delayed γ ray spectra of ^{101}Sn

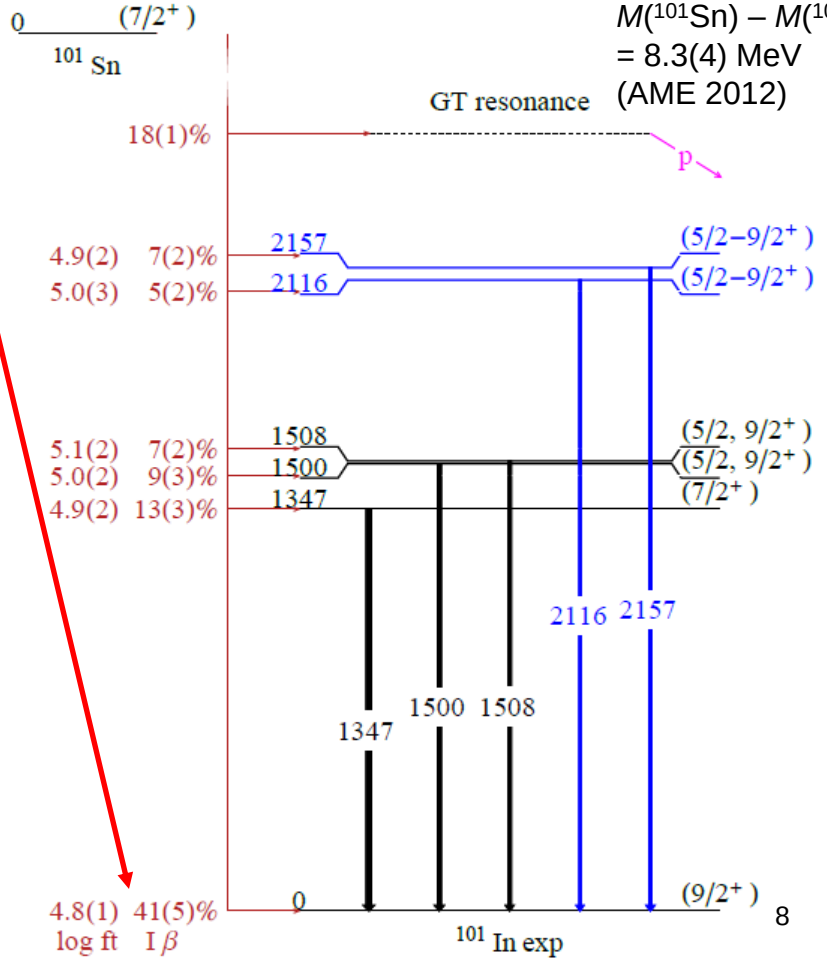
This work



K. Straub, PhD thesis, TU Munich (2010)

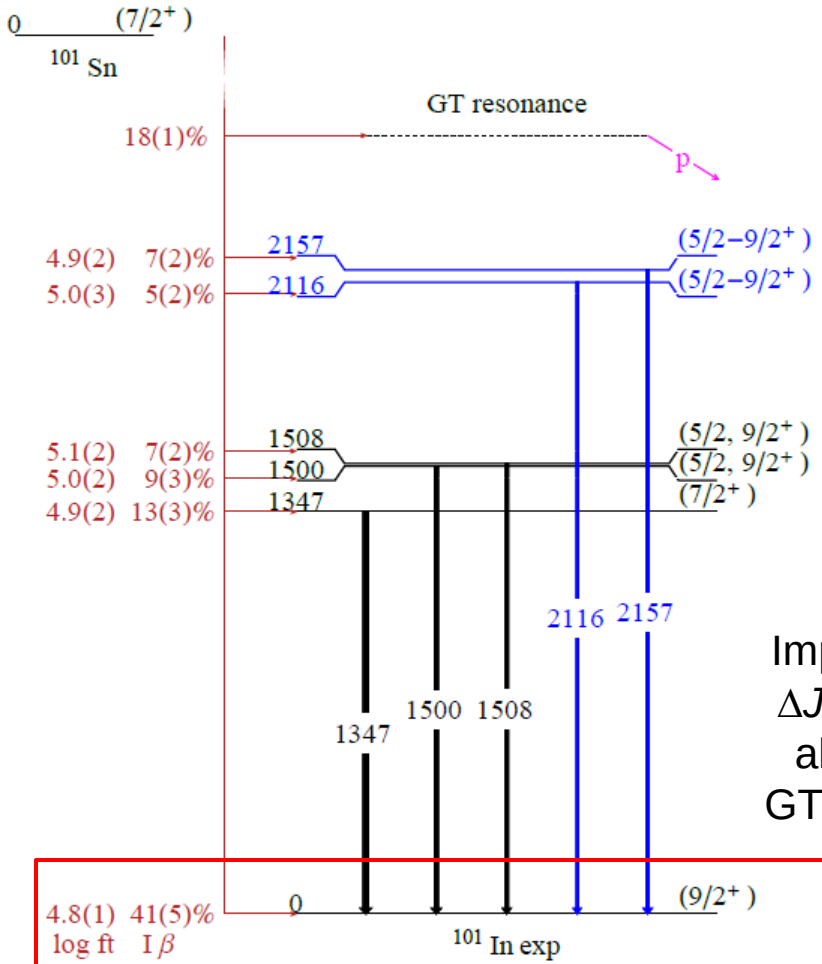


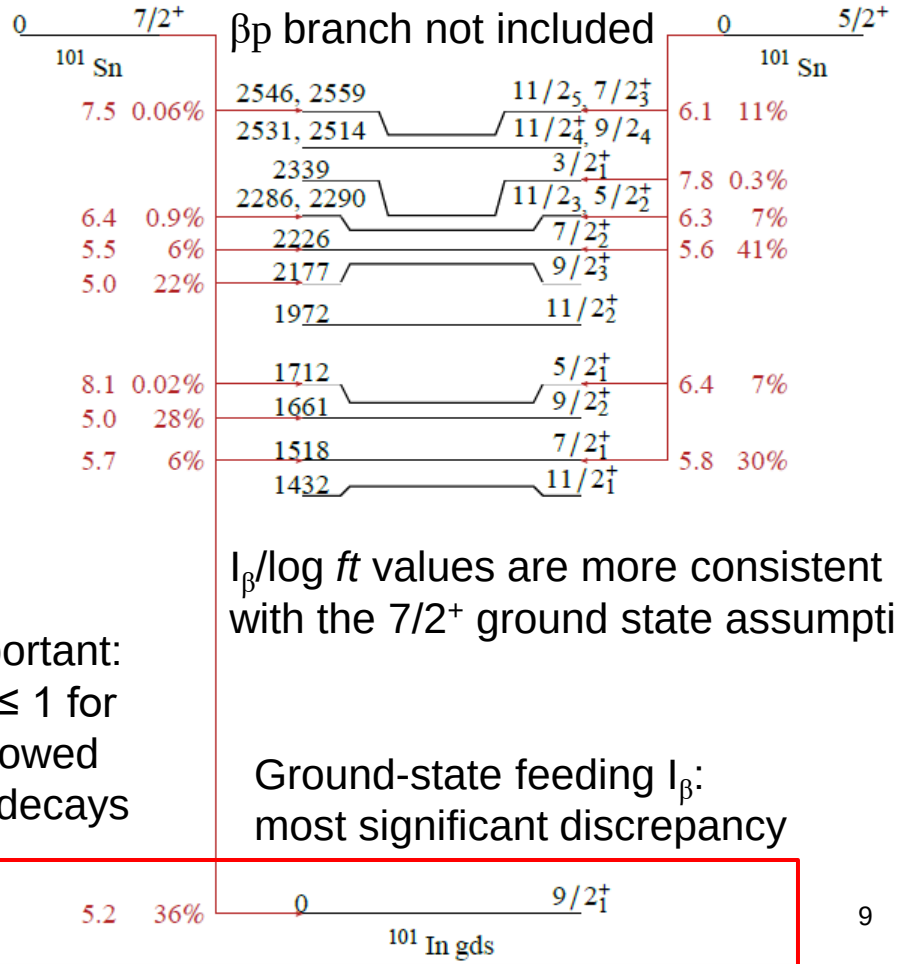
E_γ [keV]	I_γ [a]
252	0,5(1)
1281	0,4(1)
1333	0,5(1)
1347	1,0(2)
1499	0,8(2)
1508	0,2(1)



$M(^{101}\mathrm{Sn}) - M(^{101}\mathrm{In})$ = 8.3(4) MeV (AME 2012)

Discussion: comparisons to shell model





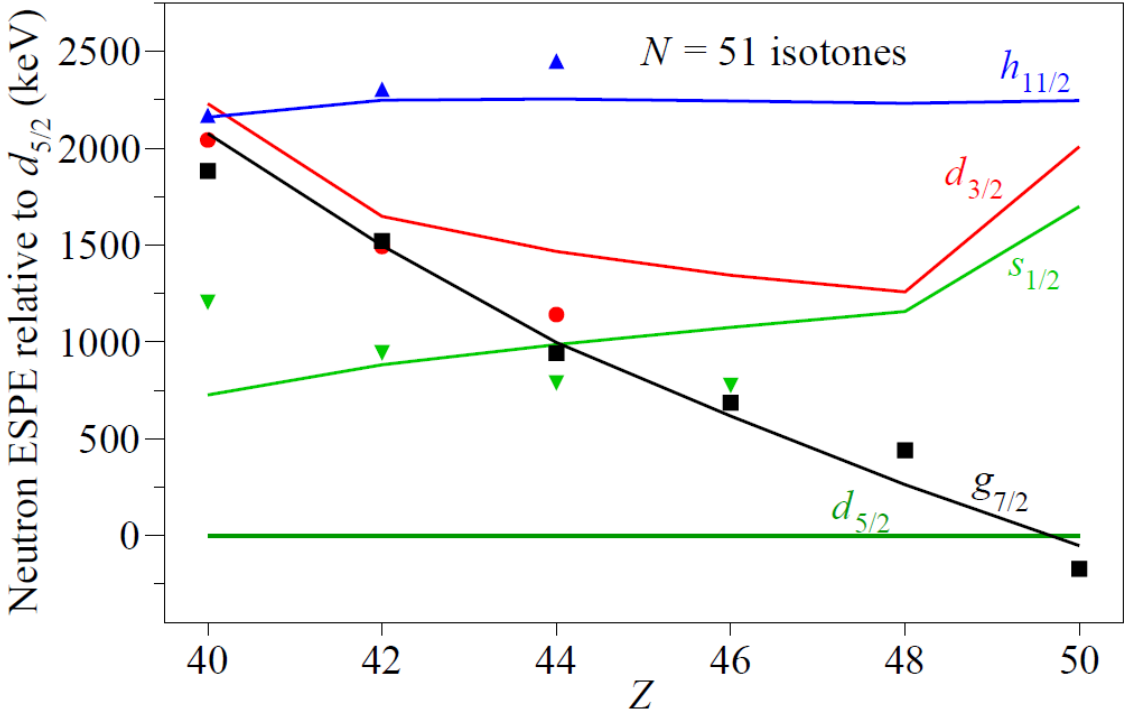
βp branch not included

I_β/log *ft* values are more consistent with the 7/2⁺ ground state assumption

Important: $\Delta J \leq 1$ for allowed GT-decays

Ground-state feeding I_β: most significant discrepancy

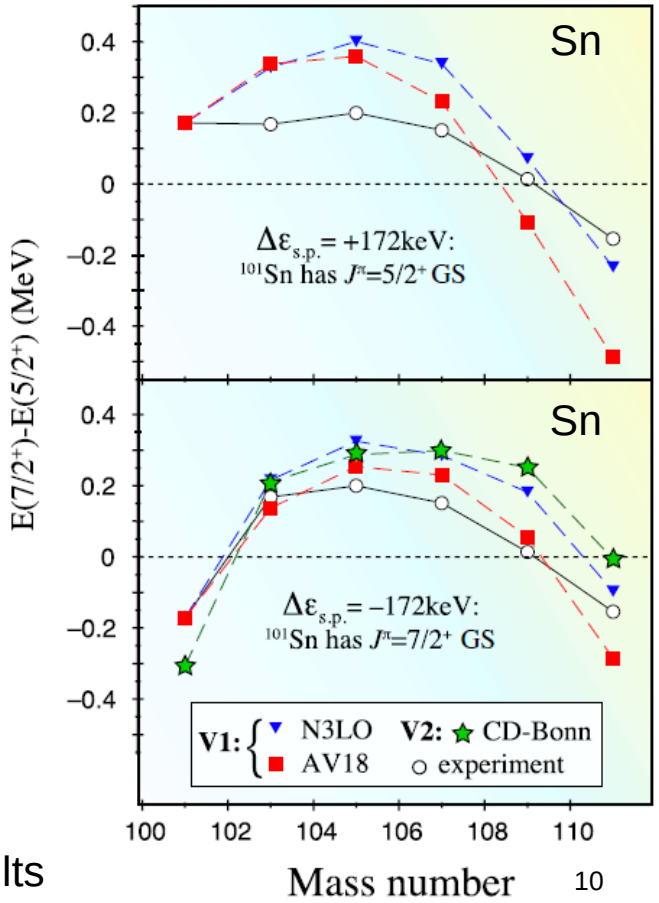
Discussion: effective single-particle energies of $g_{7/2}$, $d_{5/2}$



$E(7/2^+) - E(5/2^+) = -172(2)$ keV from α-γ spectroscopy
(other data points from ENSDF)

Trend of $g_{7/2}$ ESPE in good agreement with empirical SM results

I. G. Darby et al., PRL 105, 162502 (2010)



Summary and outlook

Ground-state spin of ^{101}Sn

- Sensitive probe of $g_{7/2}$ and $d_{5/2}$ ESPE near ^{100}Sn and two-body tensor force
- 5 γ-ray transitions observed, energies in good agreement with SM
- Evidence for significant direct β-decay branch to ($9/2^+$) ground state of ^{101}In

  $\rightarrow$ $J^\pi(^{101}\text{Sn}) = 7/2^+$, compatible with theory

Remaining task

- Address the Pandemonium effect: apparent enhancement of I_β from γ-ray analysis

  $\rightarrow$ more accurate determination of I_β to the ground state

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J. Park[1, 2], R. Krücken[1, 2], R. Gernhäuser[3], M. Lewitowicz[4], S. Nishimura[5],
H. Sakurai[6], H. Baba[5], B. Blank[7], A. Blazhev[8], P. Boutachkov[9], F. Browne[10],
I. Čeliković[4], P. Doornenbal[5], T. Faestermann[3], Y. Fang[11], G. de France[4],
N. Goel[9], M. Górska[9], S. Ilieva[12], T. Isobe[5], A. Jungclaus[13], G. D. Kim[14],
Y.-K. Kim[14], I. Kojouharov[9], M. Kowalska[15], N. Kurz[9], G. Lorusso[5], D. Lubos[3],
K. Moschner[8], I. Nishizuka[16], Z. Patel[17], M. M. Rajabali[1], S. Rice[17], H. Schaffner[9],
L. Sinclair[18], P.-A. Söderström[5], K. Steiger[3], T. Sumikama[16], Z. Wang[1],
H. Watanabe[19], J. Wu[13], and Z. Y. Xu[6]

1. TRIUMF, Canada
2. University of British Columbia, Canada
3. TU Munich, Germany
4. GANIL, France
5. RIKEN Nishina Center, Japan
6. University of Tokyo, Japan
7. CENBG, France
8. University of Cologne, Germany
9. GSI, Germany
10. Brighton University, UK
11. Osaka University, Japan
12. TU Darmstadt, Germany
13. IES CSIS, Spain
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