β-decay properties of neutron rich Ag and Cd isotopes: new data from TETRA neutron detector

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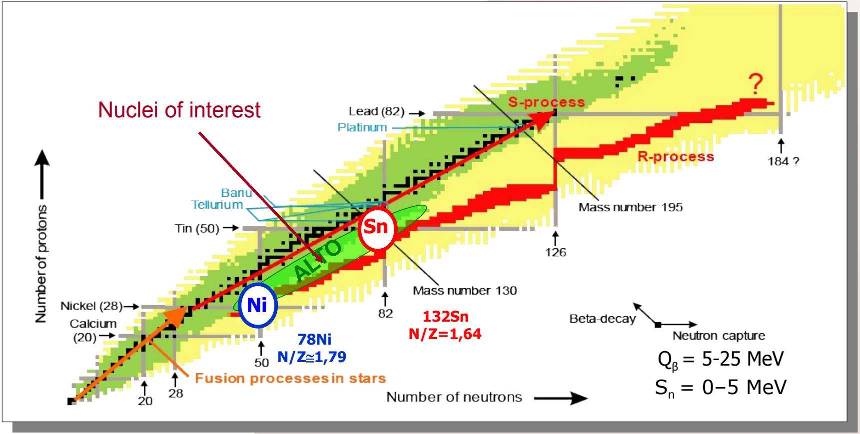
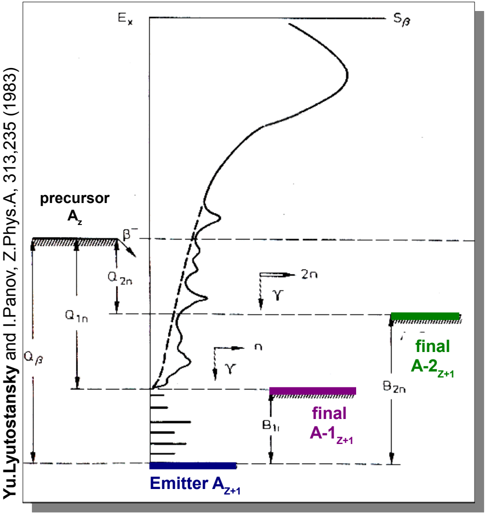
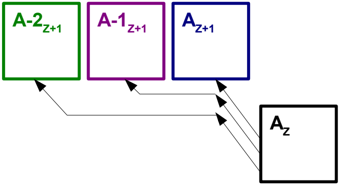
7 June 2014

Beta decay of neutron rich nuclei



Beta delayed (multi) neutron emission





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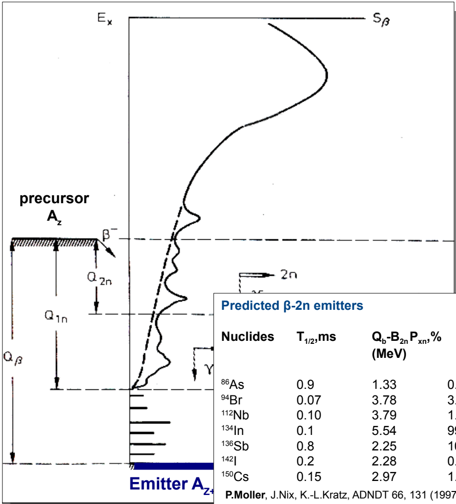


Yu.Lyutostansky and I.Panov, Z.Phys.A, 313,235 (1983)

Predicted β-2n emitters

Nuclides	$T_{1/2}$,ms	Q_b-B_{2n} (MeV)	P_{xn},%
^{86}As	0.9	1.33	0.02
^{94}Br	0.07	3.78	3.12
^{112}Nb	0.10	3.79	1.28
^{134}In	0.1	5.54	99
^{136}Sb	0.8	2.25	10.6/0.28
^{142}I	0.2	2.28	0.76
^{150}Cs	0.15	2.97	1.48

P.Moller, J.Nix, K.-L.Kratz, ADNDT 66, 131 (1997)

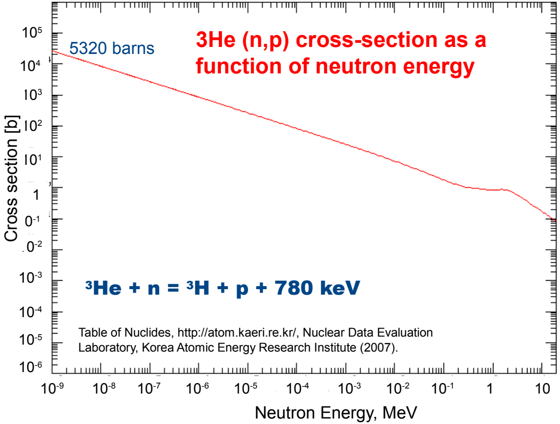
Known β-2n emitters

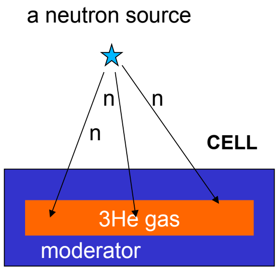
Nuclides	$T_{1/2}$,ms	xn	P_{xn},%
^{11}Li	8.5	2n	4.1(4)
		3n	1.9(2)
^{14}Be	14.5	2n	0.80(8)
		3n	0.2(2)
^{15}B	10.4	2n	0.4(2)
^{17}B	5.1	2n	11(7)
		3n	3.5(7)
		4n	0.4(3)
^{30}Na	48	2n	1.17(16)
^{32}Na	13.5	2n	8(2)
^{34}Na	5.5	2n	~ 50
^{86}Ga	43(20)	2n	20(10)
^{98}Rb	110	2n	0.38(6)
^{100}Rb	51	2n	2.7(7)

Oak Ridge, Oct 2013
(Phys. Rev. Lett. 111, 132502 2013)

Phys. Lett. B. 1980. V.94 P. 307
Phys. Rev. Lett. 1981. V.47 P.483
Nucl. Phys. 1960. V19. P482
Phys. Rev. Lett. 1979 V.43 P.1652
Data and Nucl. Data Tables. V53 P1 1993

Detectors with ³He filled counters



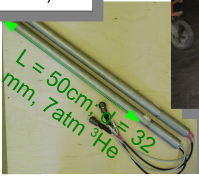


As can be seen, the cross-section is much larger for thermal neutrons (~ 0.0253 eV) than for fast neutrons (~ 1 MeV). Neutrons are born fast. Thus, to maximize the efficiency of the 3He tubes, the neutrons must be slowed (or moderated) to thermal energies. Neutron moderation is most often achieved via elastic scattering collisions with hydrogenous material. For this reason, ^{3}He tubes are often embedded in high-density polyethylene (C_6H_{12}).

Neutron detector TETRA

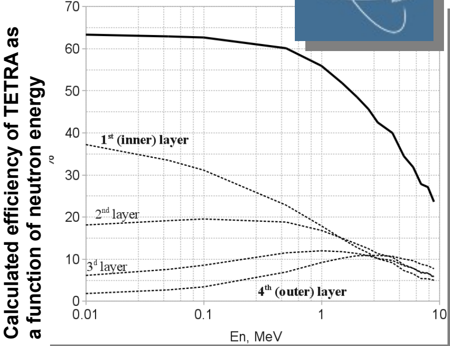
- Zero energy threshold
- Zero cross-talk(multiplicity)
- Perfect gamma separation
- Easy in use/ geometry
- High efficiency
- Low internal background

^{3}He 7 atm x 80 counters
Eff. ε~60% (<1 MeV)



	^{3}He detector	Scintillator
Neutron energy range	< 1.5 MeV	<20MeV
Neutron energy	no	yes
Threshold	0	~30÷300 keV
Cross talk	no	yes
Efficiency	30-60%	10-30%
Multiplicity	yes	?
Angl. correlation	yes	?
Time scale	μs	ns

D. Testov et al., Physics of Atomic Nuclei 72, 1 (2009)



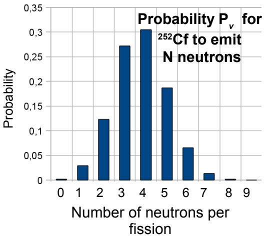
Smart efficiency calibration

M. Dakowski et al.,, Nucl. Instr&Meth. 113, 195 (1973)

$$\sum_{V=1}^{n} K_{n\nu} P_{\nu} = F_n, \quad n = 1, 2, ..., n_{max}$$

$$K_{n\nu} = \frac{\nu!}{n!(\nu - n)!} \varepsilon^n (1 - \varepsilon)^{\nu - n}$$

P_v probability to emit *v* neutron in a fission
F_n probability to detect *n* neutrons
K_{vn} transmission coefficients
ε efficiency



A. S. Vorobyev et al., AIP Conf. Proc. 769, 613 (2005)

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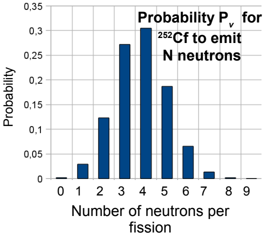

A. S. Vorobyev et al., AIP Conf. Proc. 769, 613 (2005)

P_ν probability to emit *v* neutron in a fission
F_n probability to detect *n* neutrons
K_{vn} transmission coefficients
ε efficiency

N_j number of events with *j≠i* neutrons emitted within ***N_{dec}*:**

$$N_i = N_{dec} * F_i = N_{dec} \sum_{\nu=i}^{\nu_{max}} \frac{\nu!}{i!(\nu-i)!}\varepsilon^i(1-\varepsilon)^{\nu-i}P_\nu$$

N_{dec} number of decays
N_i number of events with *i* neutrons emitted within ***N_{dec}***

$$\frac{N_i}{N_j} = \frac{F_i}{F_j} = f(\varepsilon)$$

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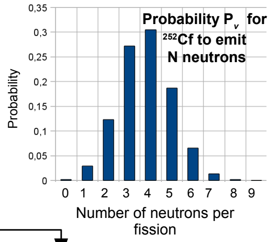
$$\frac{N_i}{N_j} = \boxed{\frac{F_i}{F_j}} = f(\varepsilon)$$

calculated



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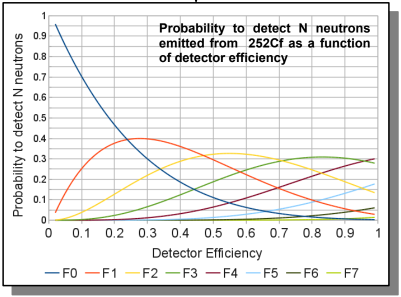

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N_j number of events with $j{\neq}i$ neutrons emitted within N_{dec}:

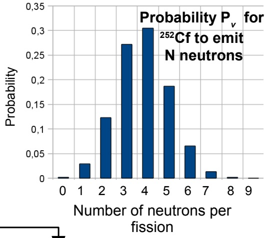
N_{dec} number of decays

N_i number of events with i neutrons emitted within N_{dec}

$$\frac{N_i}{N_j} = \frac{F_i}{F_j} = f(\varepsilon)$$

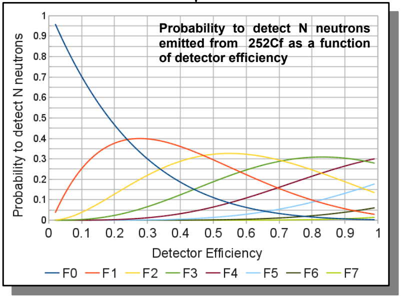
calculated

measured

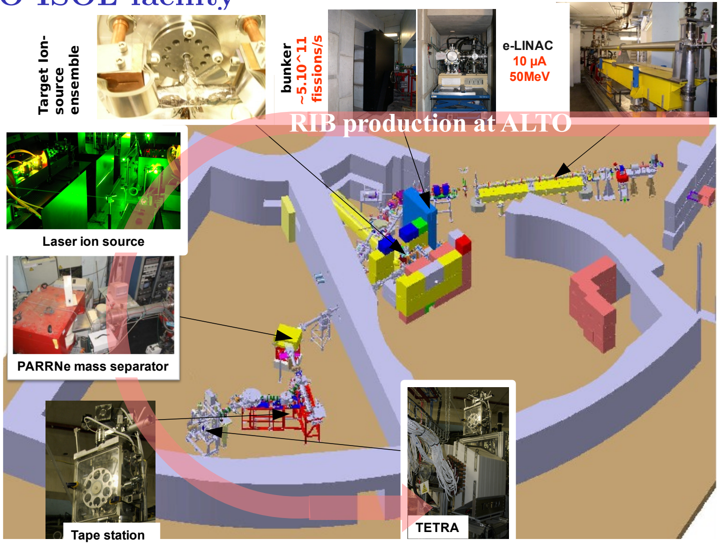


A. S. Vorobyev et al., AIP Conf. Proc. 769, 613 (2005)

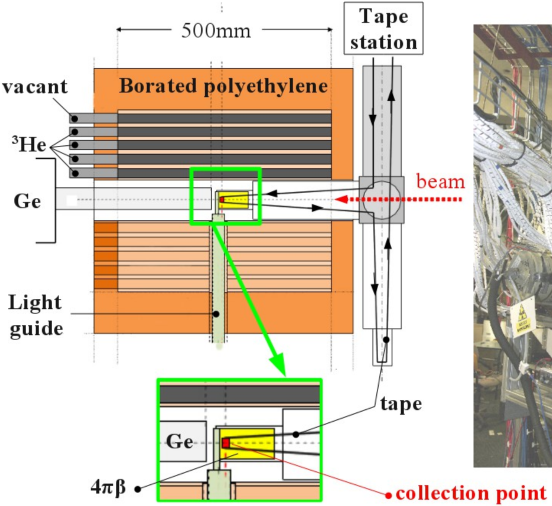
Eff	N2/N3	N2/N4	N3/N4
exp.	1.58(1)	4.10(3)	2.59(2)
0.51	1.62	4.49	2.77
0.52	1.58	4.26	2.69
0.53	1.54	4.04	2.63
0.54	1.5	3.83	2.56
0.55	1.46	3.64	2.5



ALTO ISOL facility

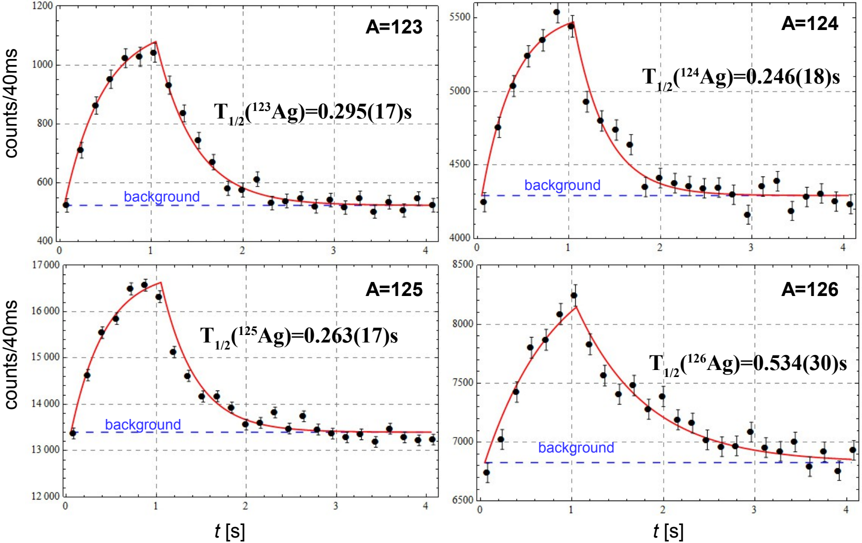


Experimental setup



D. Testov et al., World Sci., Conf. Proc. 47, 365 (2013)

Results: $^{123-125}$Ag, ^{126}Cd



Comparison to priviously quated

	$T_{1/2}$, [s]	method	P_n, [%]	comment
^{123}**Ag**	0.295(17)	n	0.60(25)	present
	0.272(24)	b	1.0(5)	MSU, [1]
^{124}**Ag**	0.246(18)	n	-	present
	0.187(14)	b	1.3(9)	MSU, [1]
	0.172(5)	n	-	ISOLDE, [4]
	0.170(30)	γ	-	TRISTAN, [2]
	0.540(8)	n	-	TRISTAN, [3]
^{125}**Ag**	0.263(17)	n	-	present
	0.166(7)	n	-	ISOLDE, [4]
^{126}**Cd**	0.534(30)	n	0.04(1)	present
	0.600(30)	γ	-	Studvik, [5]
	0.510(10)	γ	-	OSIRIS, [6]
	0.506(15)	γ		TRISTAN, [7]

[1] F.Montes, A.Estrade, P.T. Hosmer et al., Phys. Rev. C **73** 035801 (2006)
[2] John C. Hill, F.K. Wohn, Z. Berant Phys. Rev. C **29** 1078 (1984)
[3] P. L. Reeder, R. A. Warner, and R. L. Gill Phys. Rev. C **27** 3002 (1983)
[4] V.N.Fedoseyev, Y.Jading, O.C.Jonsson Z.Phys.A **353** 9 (1995)
[5] H.Göktürk, B. Ekström E.Lund and B. Fogelberg Z.Phys.A **324** 117 (1986)
[6] G. Rudstam, P. Aagaard, P. Hoff et al., Nucl. Instr&Meth. 186, 365 (1981)
[7] M. L. Gartner and J. C. Hill, Phys. Rev. C 18, 1463 (1978)

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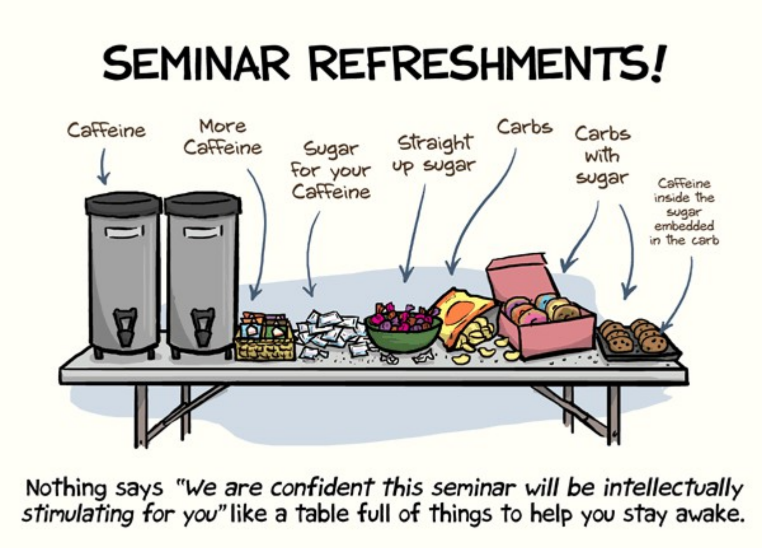
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More Caffeine
Sugar for your Caffeine
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Carbs
Carbs with sugar
Caffeine inside the sugar embedded in the carb
Nothing says "We are confident this seminar will be intellectually stimulating for you" like a table full of things to help you stay awake.

Thank you!


A Guide to Academic Relationships
Same department, different field = "Colleague"
Same topic, different field = "Collaborator"
Same field, different topic = Conference Buddy
Different field, different topic = Who cares?
Same field, same topic = Bitter Enemy
(a.k.a. also "Collaborator")
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