New measurements of M1 and E2 transition strengths below ^{100}Sn

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CENTER FOR EXOTIC NUCLEAR STUDIES

IDATEN workshop

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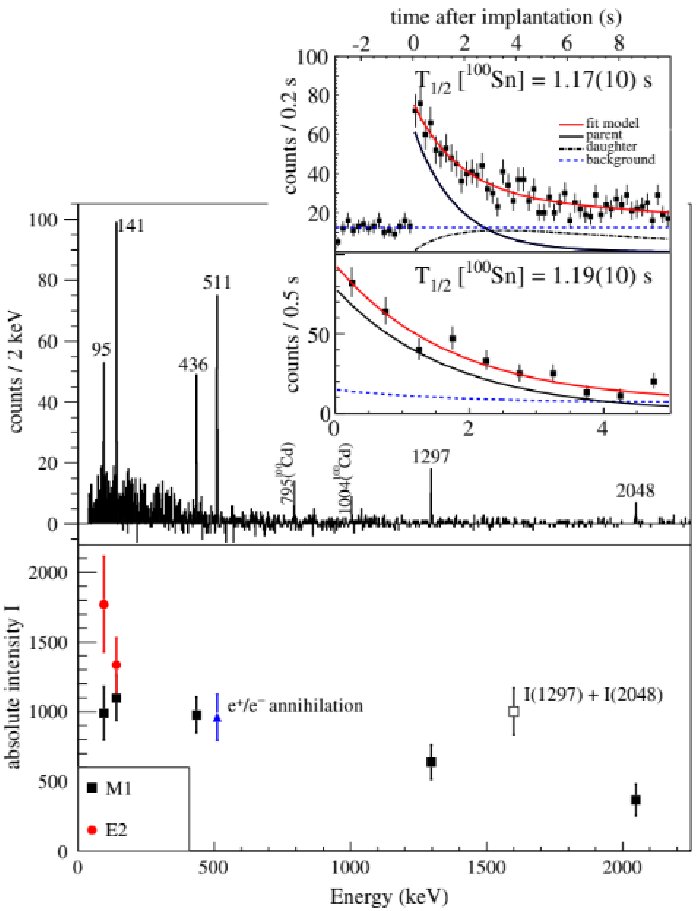
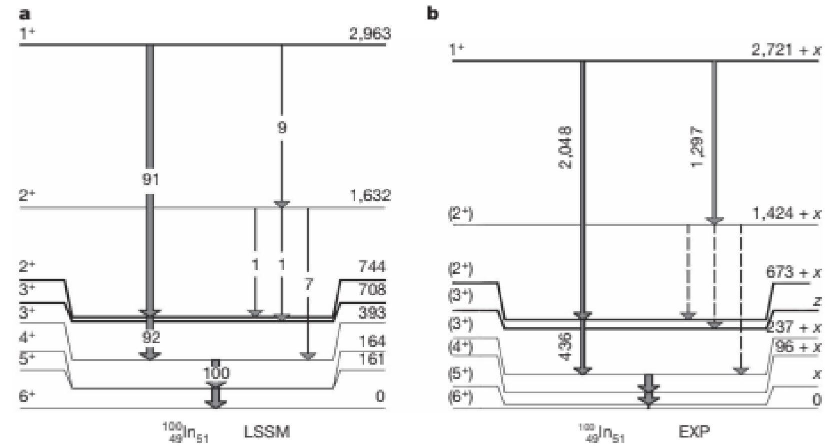
Physics motivation – ^{100}In

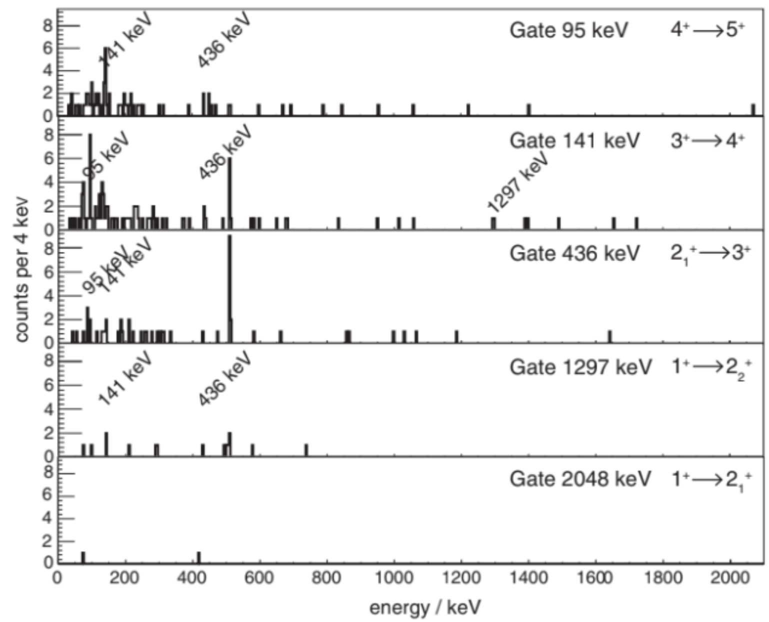
Level scheme of ^{100}In, β^+/EC daughter of doubly magic ^{100}Sn: still to be addressed



D. Lubos et al., PRL 122, 222502 (2019)

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



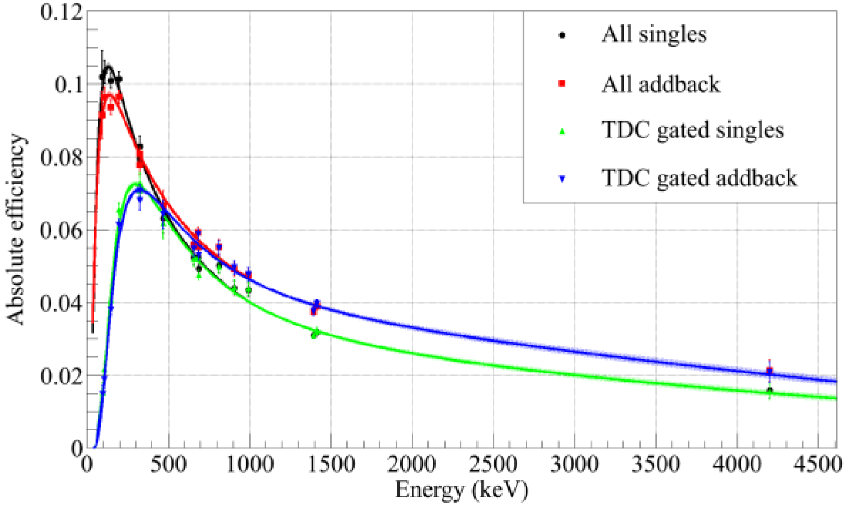


Partial γγ coincidence results

Improving on the EURICA campaign

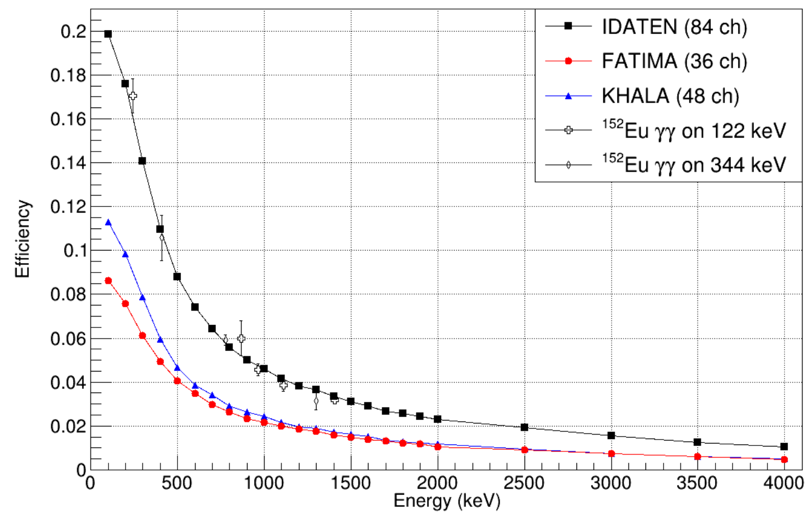
^{124}Xe beam intensity increase: 30 pnA (2013) → 140 pnA (now)

Measured EURICA efficiency



J. Park, PhD thesis (2017)

Simulated IDATEN efficiency



Great enhancement below 500 keV

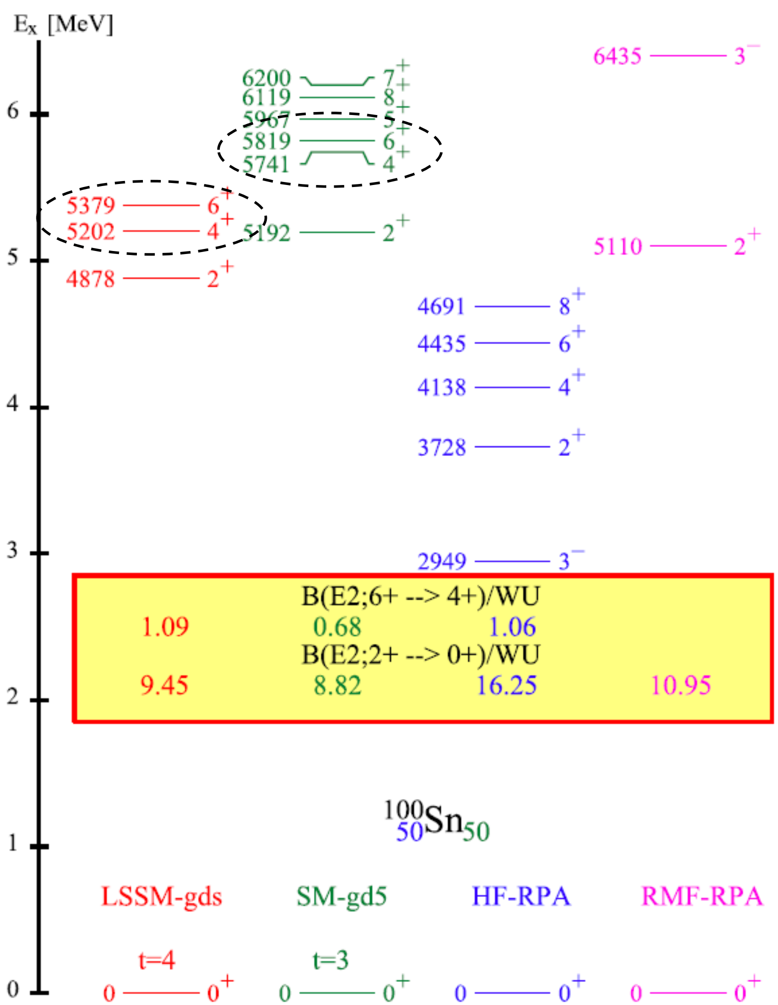
Expected statistics to increase by factor of 5-8 compared to the previous data

Possible ordering and B(M1) measurements of 96/141/436-keV transitions in ^{100}In

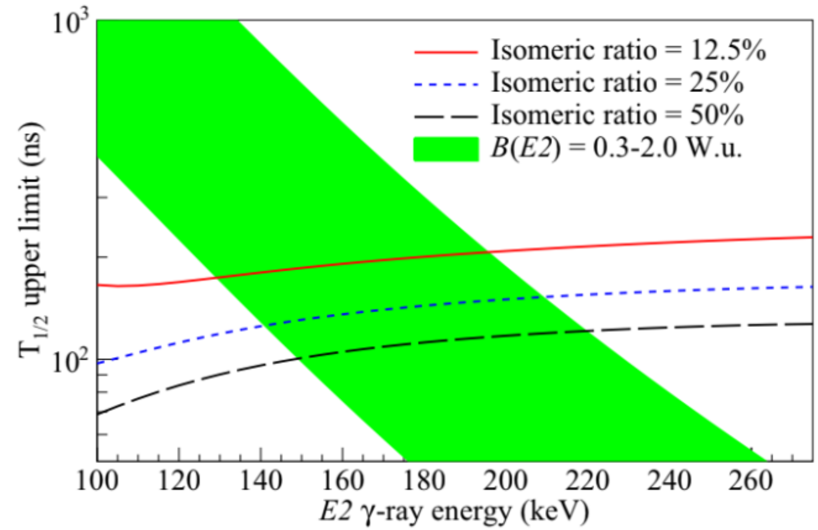
Physics motivation – ^{100}Sn

Search for core-excited isomer in doubly magic ^{100}Sn

T. Faestermann et al. / Progress in Particle and Nuclear Physics 69 (2013) 85–130



Only limits so far with help from SM



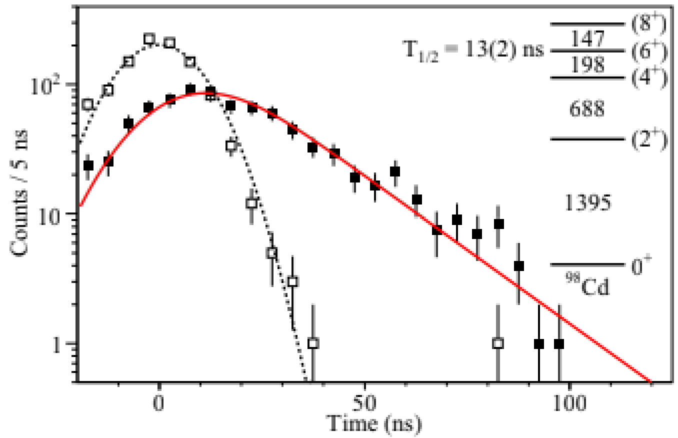
JP et al., PRC 96, 044311 (2017)

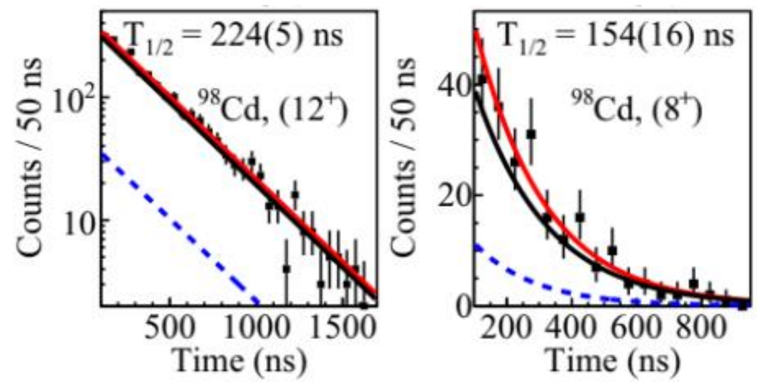
Assuming 25% isomeric ratio,

- E_γ > 140 keV
- $T_{1/2}$ < 150 ns

Physics case of ^{98}Cd (N = 50)

$T_{1/2}$ measured for 8^+ and 6^+ seniority states and core-excited 12^+ state in ^{98}Cd





JP et al., PRC 96, 044311 (2017)

NuShellX calculation with SLGM interaction

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2.183     4+    1    14.821988    0.3077E-04      6.038      -12.31   ---------------------

      Ef     Jf   nf    BR        Eg        del    B(1)       B(2)        A_p       A_n
      1.413    2+    1  100.0000   0.770    999.00   0.0000E+00   0.1410E+03    -23.750     0.000

2.465     6+    1    0.3252E+04    0.1403E-06      9.055       7.73   ---------------------

      Ef     Jf   nf    BR        Eg        del    B(1)       B(2)        A_p       A_n
      2.183    4+    1  100.0000   0.282    999.00   0.0000E+00   0.9754E+02     23.738     0.000

2.577     0+    2     3.443878    0.1324E-03      0.000       0.00   ---------------------

      Ef     Jf   nf    BR        Eg        del    B(1)       B(2)        A_p       A_n
      1.413    2+    1  100.0000   1.164    999.00   0.0000E+00   0.7686E+02     -5.845     0.000

2.598     8+    1    0.3480E+06    0.1311E-08     12.074      38.67   ---------------------
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$T_{1/2}$ (ps)

15 ps predicted vs ???

$T_{1/2}(4^+)$ in ^{96}Pd = 1.01(1) ns

3.3 ns predicted vs 13(2)

$T_{1/2}(6^+)$ in ^{96}Pd = 6.3(6) ns

^{96}Pd isomer $T_{1/2}$ results reference:
H. Mach et al., PRC 95, 014313 (2017)

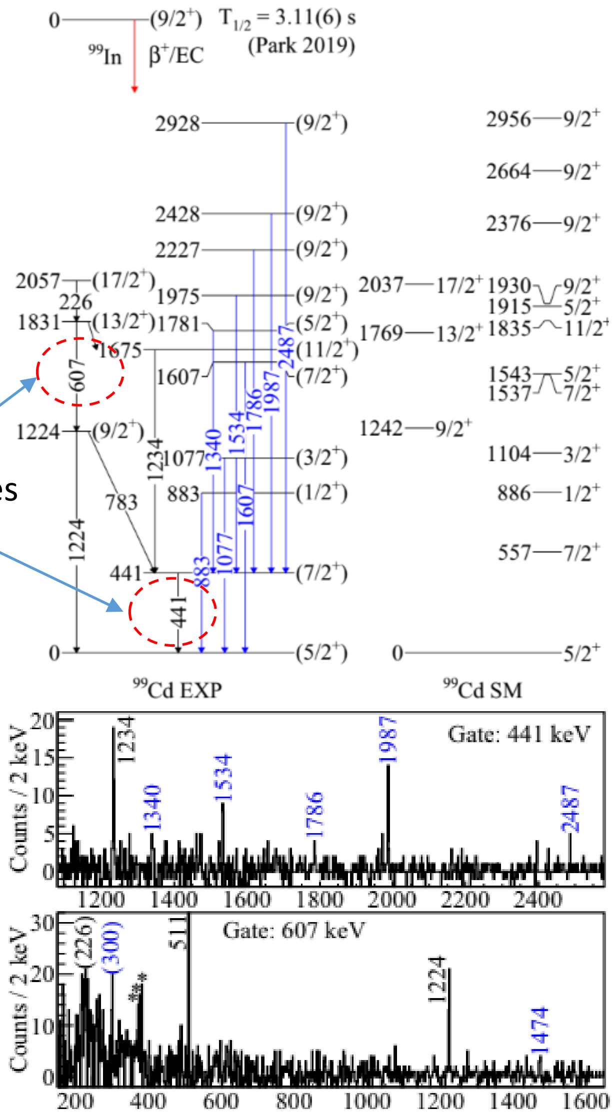
348 ns predicted vs 154(16) ns

Physics case of ^{99,100}Cd

Ideal to investigate systematics of seniority state half-lives in ^{99,100}Cd and compare with ^{96,98}Cd

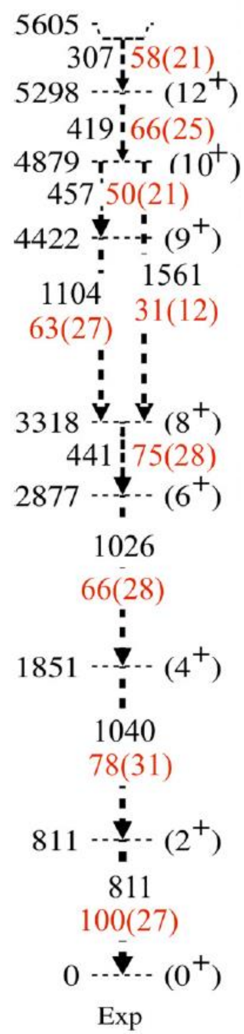
13.1(5) ns

Clean gates

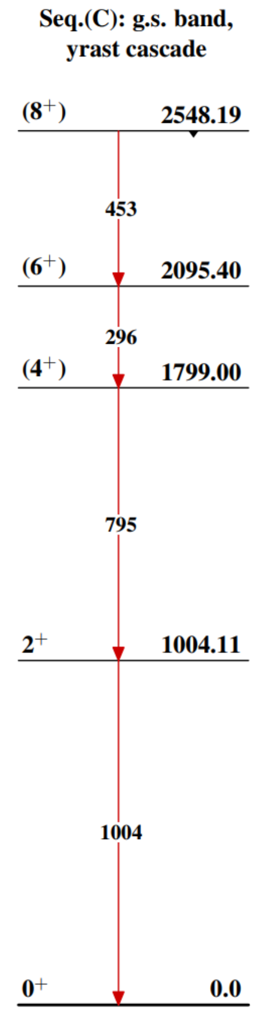


JP et al., PRC 102, 014304 (2020)

P. J. Davies et al., PRC 99, 021302(R) (2019)



^{96}Cd



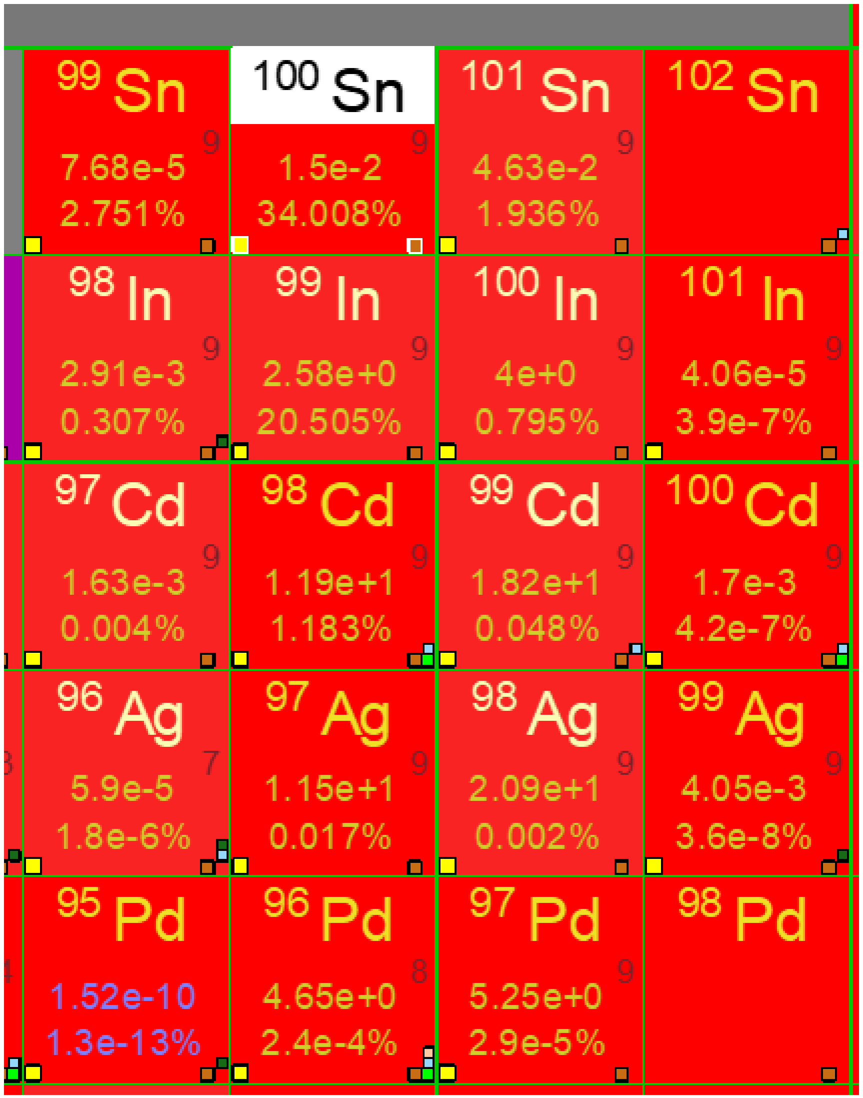
^{100}Cd

$T_{1/2}$ = 62(6) ns

$T_{1/2}$ measurable

> 1 ps (ENSDF)

LISE++ RIB production setting



Primary beam:
^{124}Xe beam, 140 pnA

Dipole magnet settings: ^{100}Sn

F1 slit adjustment: -27 mm
F3 slit adjustment: +3 mm

Nuclei of interest and rates:
- ^{100}Sn: 1.5e-2 pps
- ^{98}Cd: 11.9 pps
- ^{99}In→^{99}Cd: 2.58 pps
- ^{100}In→^{100}Cd: 4 pps

Overall rate on WAS3ABi: 79.1 pps

Feasibility calculations – ^{100}Sn, ^{100}In

Largely impacted by isomeric ratio and $T_{1/2}$ of hypothetical isomer
(lost through BigRIPS + ZeroDegree)

$LaBr_3$ instead of HPGe → better atomic background separation?

	100Sn				
Beam time (days)	6				
Production rate	1.50E-02				
implantation counts	7.78E+03				
isomeric ratio	0.25				
Half-life (ns)	100				
flight time (ns)	610				
surviving isomers	28				
	6 to 4, 200 keV	4 to 2, 400 keV	2 to 0, 4000 keV		
IDATEN efficiency	0.18	0.11	0.01		
gammas	5.1	3.1	0.3		
Beta decay correlation eff	0.5				
decays to 100In	3.89E+03				
100In gamma energies (keV)	96	141	436	1297	2048
alpha_tot (M1)	0.573	0.196	0.01017	0	0
IDATEN efficiency	0.2	0.18	0.1	0.038	0.021
counts	494	585	385	148	82
96-others coinc		74.4	44.0	9.4	2.0

Statistically significant coincidence relationships up to 1297-keV gamma

Feasibility calculations – $^{98,99,100}Cd$

Isomer | Beta decay of (6^+) ground state

	98Cd		100In		
Beam time (days)	6		Beam time (days)	6	
Production rate	1.19E+01		Production rate	4	
implantation counts	6.17E+06		implantation counts	2.07E+06	
isomeric ratio	0.9		Beta decay correlation eff	0.5	
Half-life (ns)	156				
flight time (ns)	610				
surviving isomers	369275		decays to 100Cd	1.04E+06	
Gamma energies	6 to 4, 198 keV	4 to 2, 688 keV	100Cd gamma energies (keV)	4 to 2, 794 keV	2 to 0, 1004 keV
IDATEN efficiency	0.2	0.065		0.075	0.047
internal conversion	0.1333	0.00279		0	0
gammas (singles)	65168	23936		77760	48730
gammas (coincidence)		**4236**			**3655**

>3000 coincidence counts for both ^{98}Cd, ^{100}Cd
(+ additional branching ratios of 6^+ states)

99In		
Beam time (days)	6	
Production rate (pps)	2.58	
Implantation counts	1337472	
Correlation efficiency	0.5	
Decays to 99Cd	668736	
99Cd gamma energies	1234	607
Branching ratio	0.113	0.134
Efficiency	0.038	0.075
stop gamma	441	1224
efficiency	0.1	0.038
Gamma-gamma coincidences	**287**	**255**

~300 coincidence counts in ^{99}Cd

Summary of aims

^{100}Sn

- βγ spectroscopy of ^{100}In: new (weak) transitions, ordering and B(M1) values of 96/141/436-keV γ rays through $T_{1/2}$
- 6^+ isomer search

^{98}Cd

- $T_{1/2}$ and B(E2) of 4^+ state

^{99}Cd

- $T_{1/2}$ of $7/2^+$ and $(9/2^+)$ states: B(M1) and B(E2), respectively

^{100}Cd

- B(E2) of 6^+, 4^+, and (2^+) states for comparisons with $^{96,98}Cd$