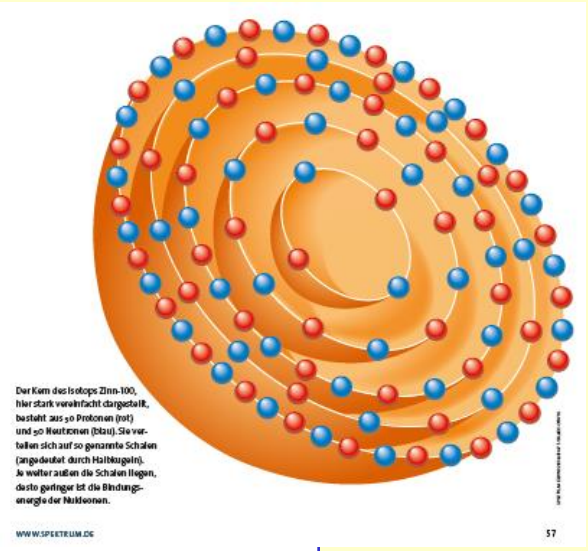
Nuclear Structure of the Doubly Magic ^{100}Sn and its Neighbors

Decay Spectroscopy at EURICA

Roman Gernhäuser, TU-München



introduction
isotope production
EURICA@RIBF
selected results
expected results

Motivation

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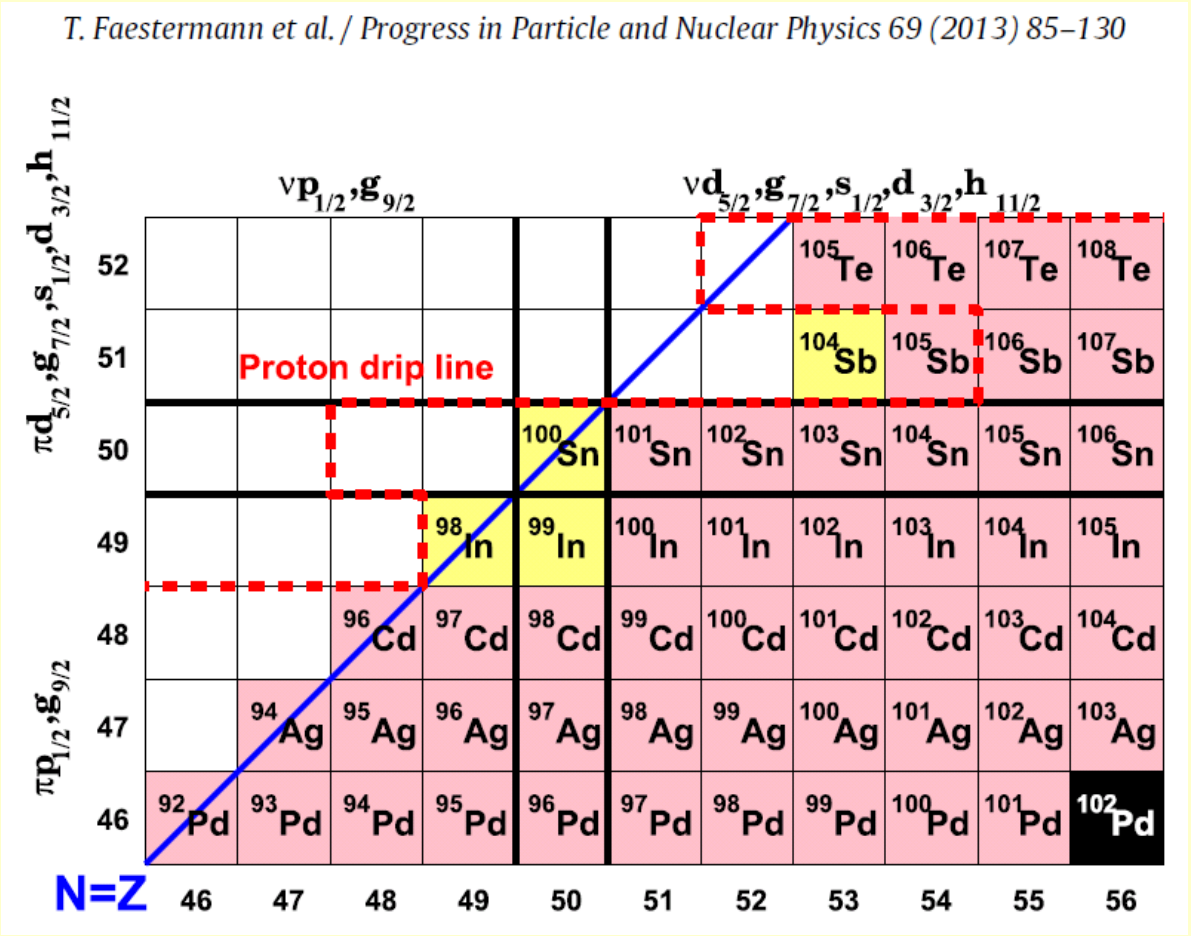
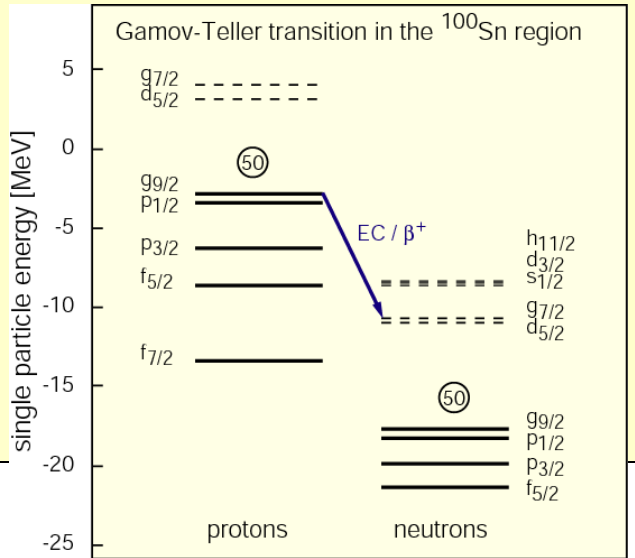


D. Bazin et al., Phys. Rev. Lett. 101, 252501 (2008)
C.B. Hinke et at., Nature 486, 341–345, (2012) **, and many others!**

N=Z
super allowed Fermi decay
super allowed GT decay
isobaric analogue states
and pn interaction

rp – process
proton drip line
βp and p – decay
$t_{1/2}$ and branching ratios



Rising at GSI

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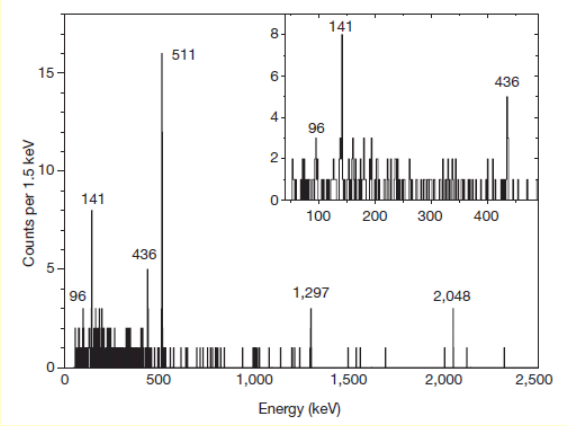
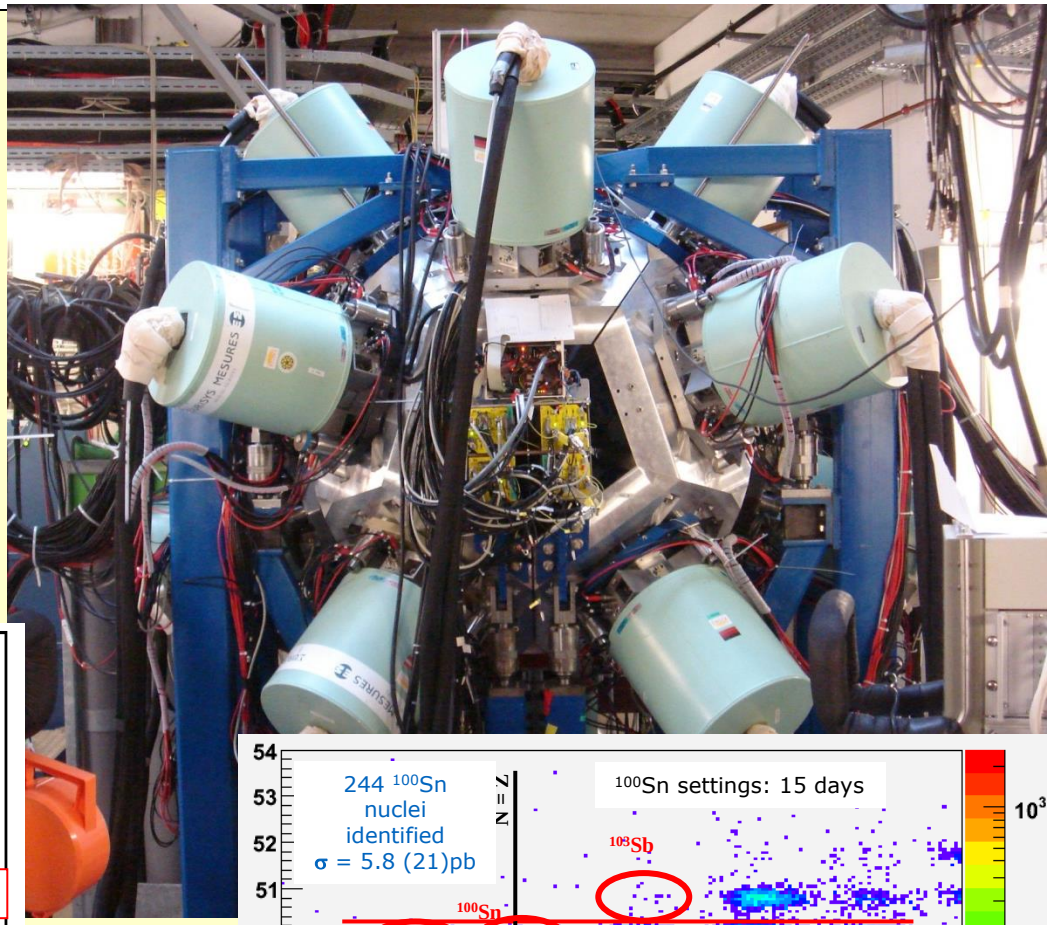
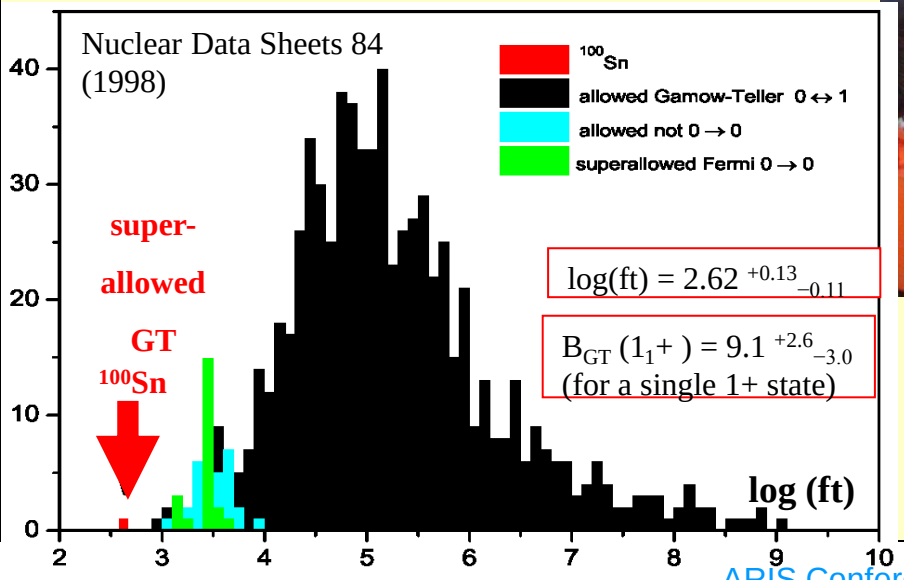
Superallowed Gamow–Teller decay of the doubly magic nucleus ^{100}Sn
Ch. Hinke et at., Nature 486, 341–345, June 2012

Decay γ spectrum of ^{100}Sn



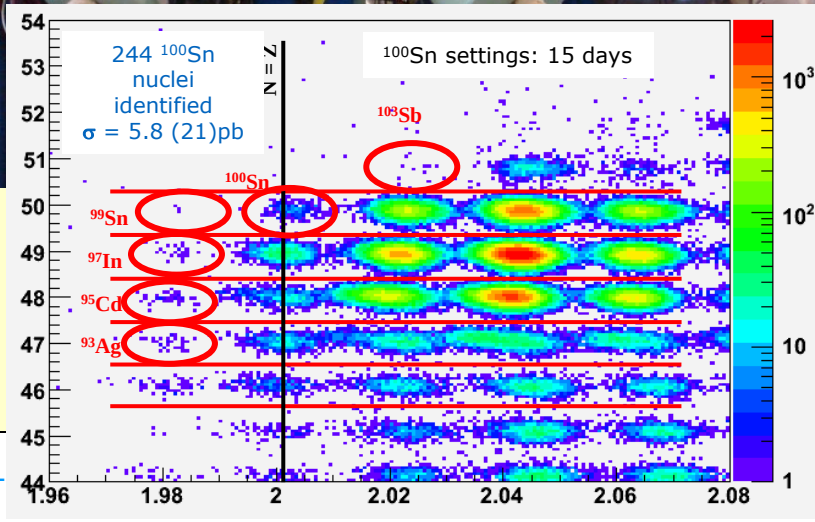


Nuclear Data Sheets 84 (1998)

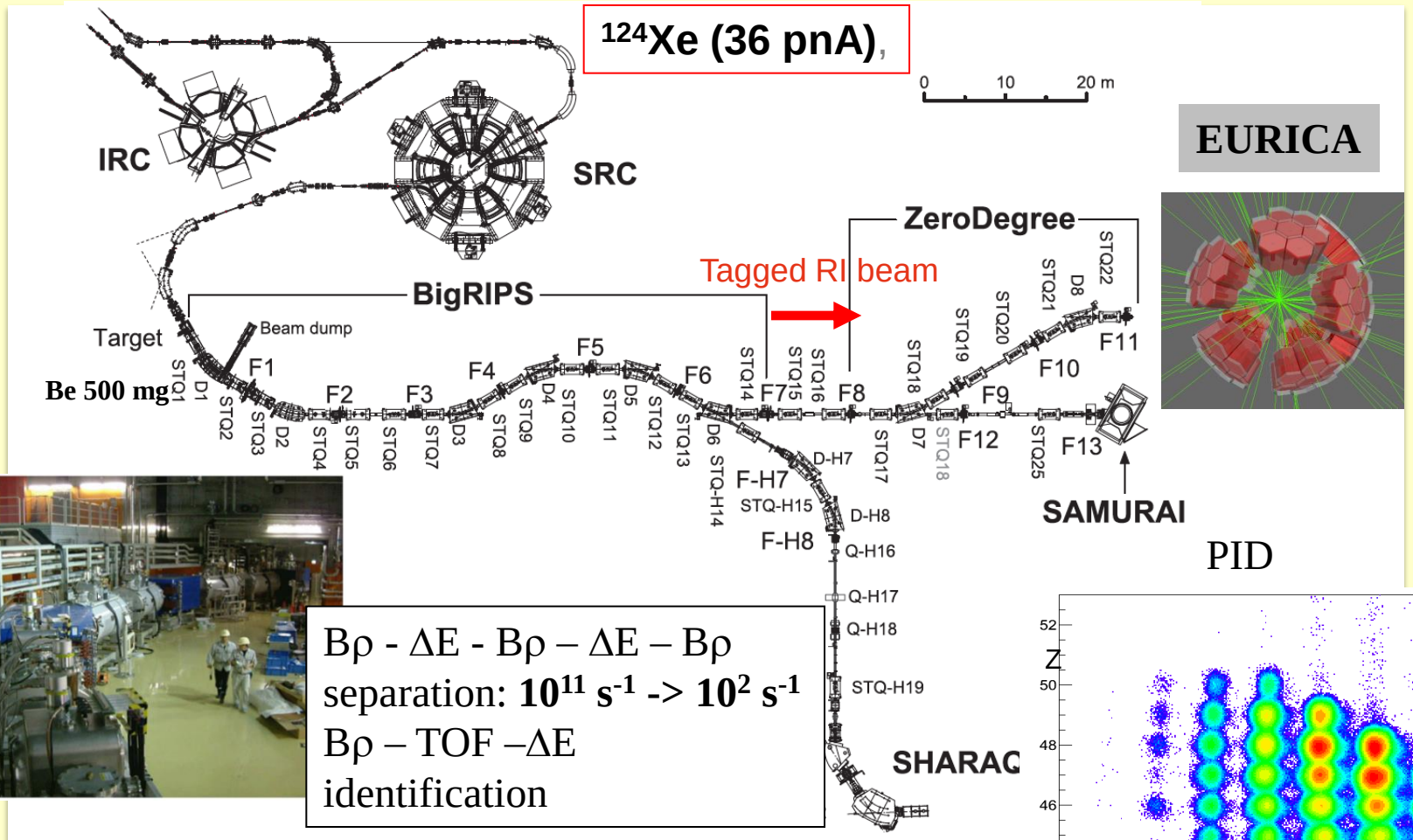


$\log(ft) = 2.62\ ^{+0.13}_{-0.11}$

$B_{GT}(1_1^+) = 9.1\ ^{+2.6}_{-3.0}$
(for a single 1+ state)

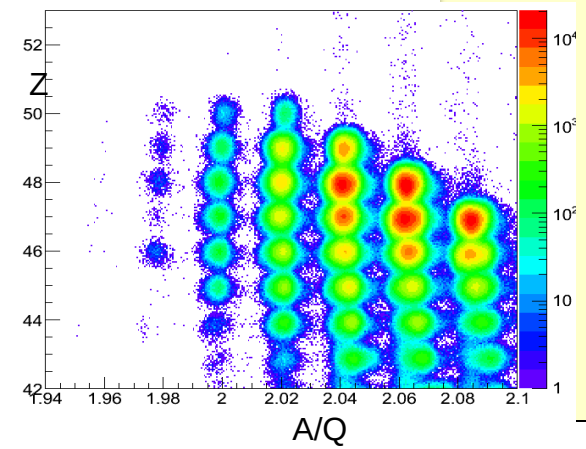


Experiment Area



Bρ - ΔE - Bρ – ΔE – Bρ
separation: 10^{11} s^{-1} -> 10^{2} s^{-1}
Bρ – TOF –ΔE
identification

PID



courtesy of S. Nishimura

EURICA (EUroball-RIKEN Cluster Array)

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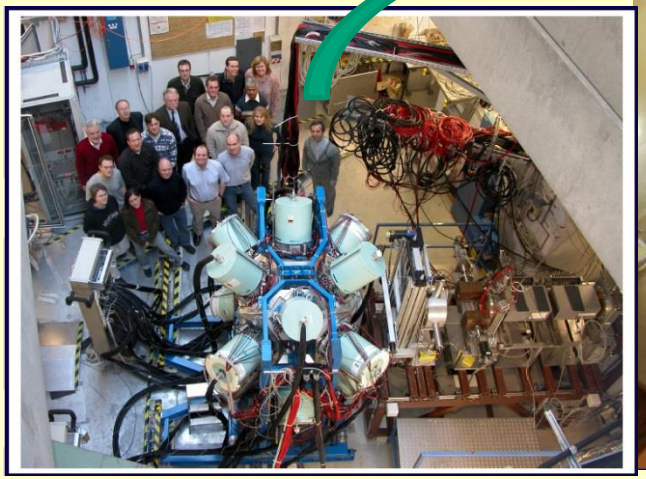
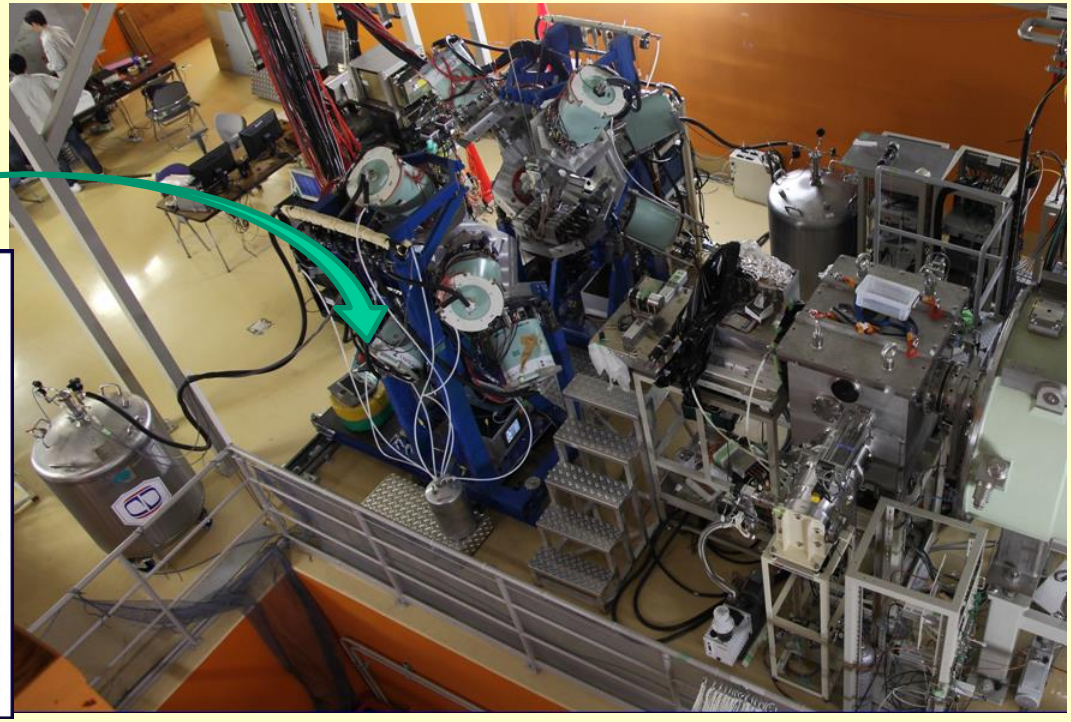
12 EUROBALL Cluster detectors, i.e. 84 Ge crystals





Euroball Cluster detectors
Support structure
Readout electronics
used for GSI-RISING

RIKEN RIBF (Japan)

Installation completed in 2012 Feb.

courtesy of S. Nishimura

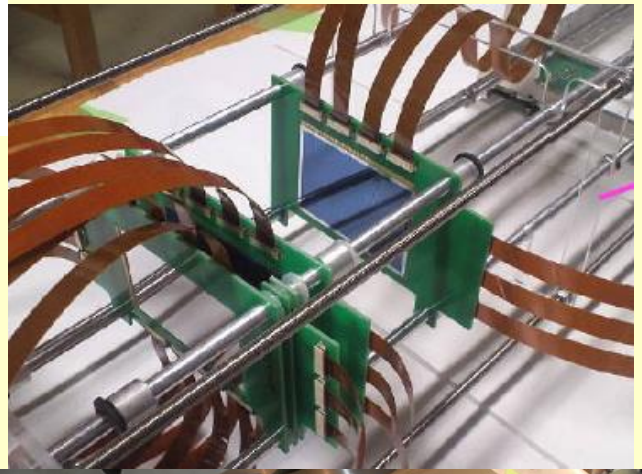
WAS3ABI for ^{100}Sn

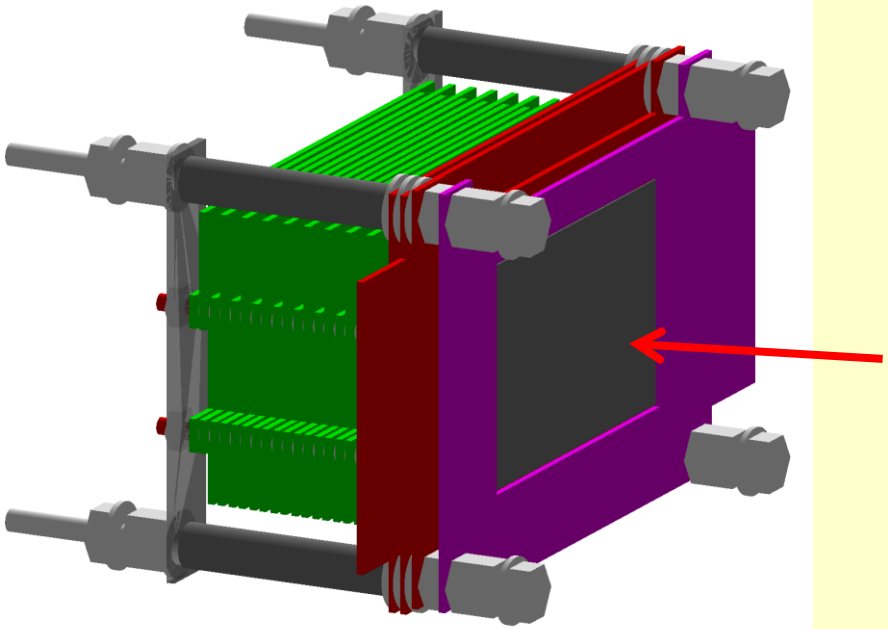
Lehrstuhl E12

(Wide-range Active Silicon-Strip Stopper Array for Beta and Ion detection)

3 layers of 1mm DSSSDs
(40-strips x 60 strips)
10 layers of 1mm SSSDs (7str)
design: TU-München/RIKEN

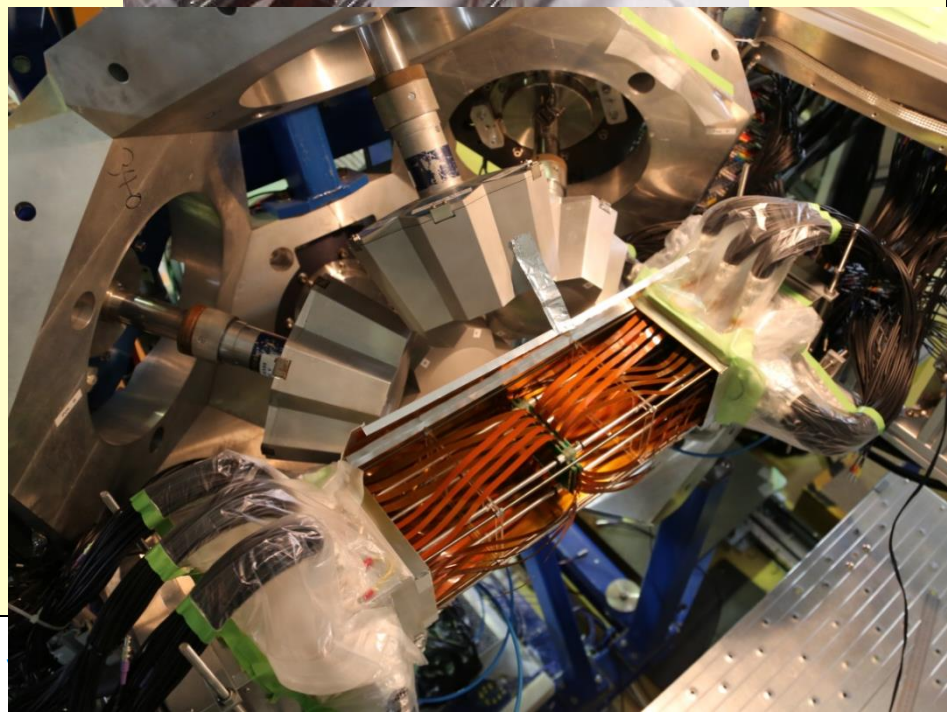
In total, 7,200 pixels
+ 70 SSD strips





Decay
10 x 1mm

Implantation
3 x 1mm



courtesy of K. Moschner

RIB Production

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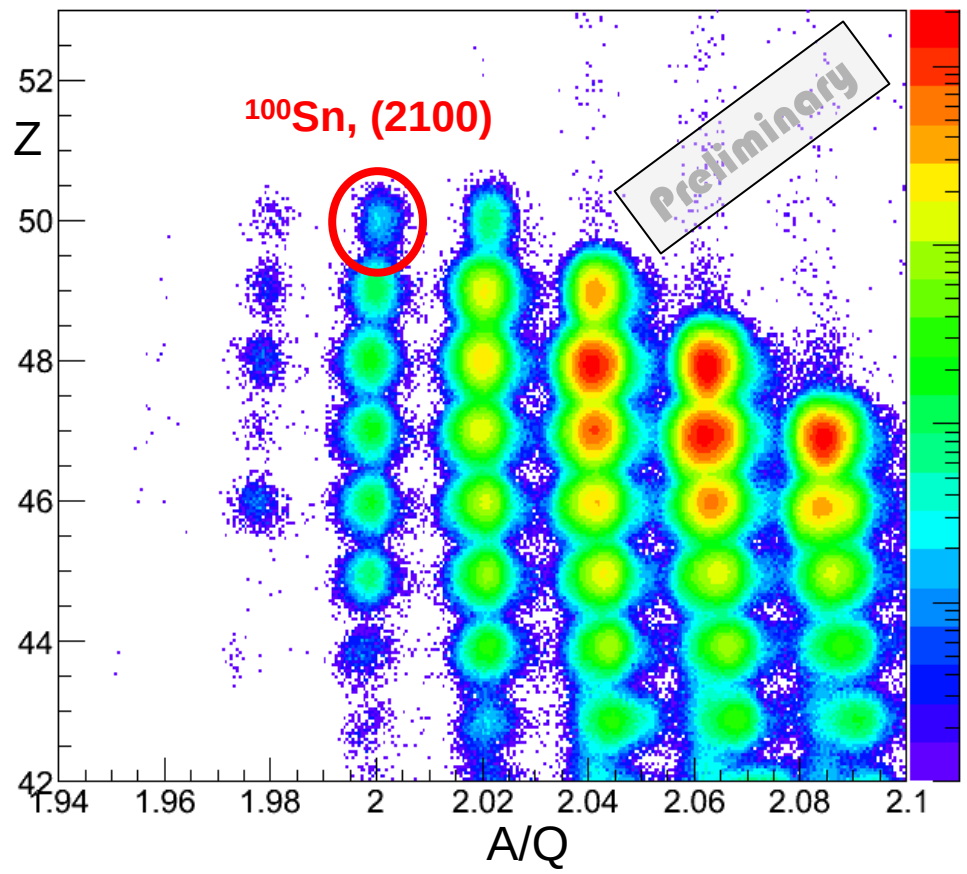
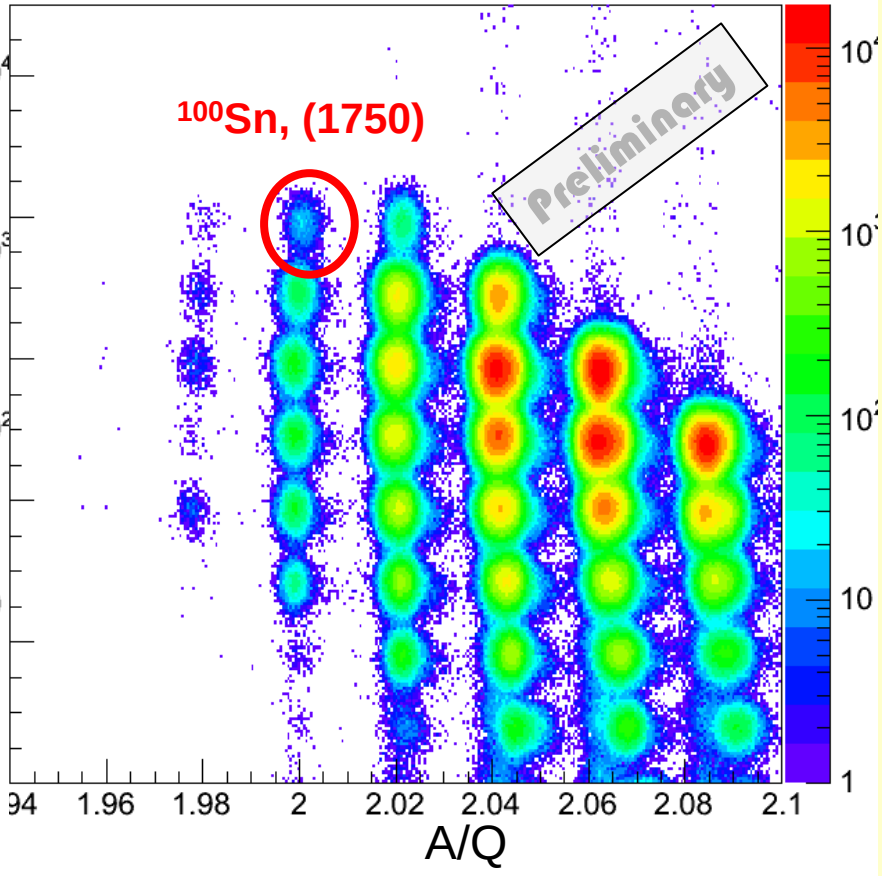
Ions reaching the final focal plane



Ions correctly implanted in WAS3ABI



Cross-Sections ^{124}Xe + Be

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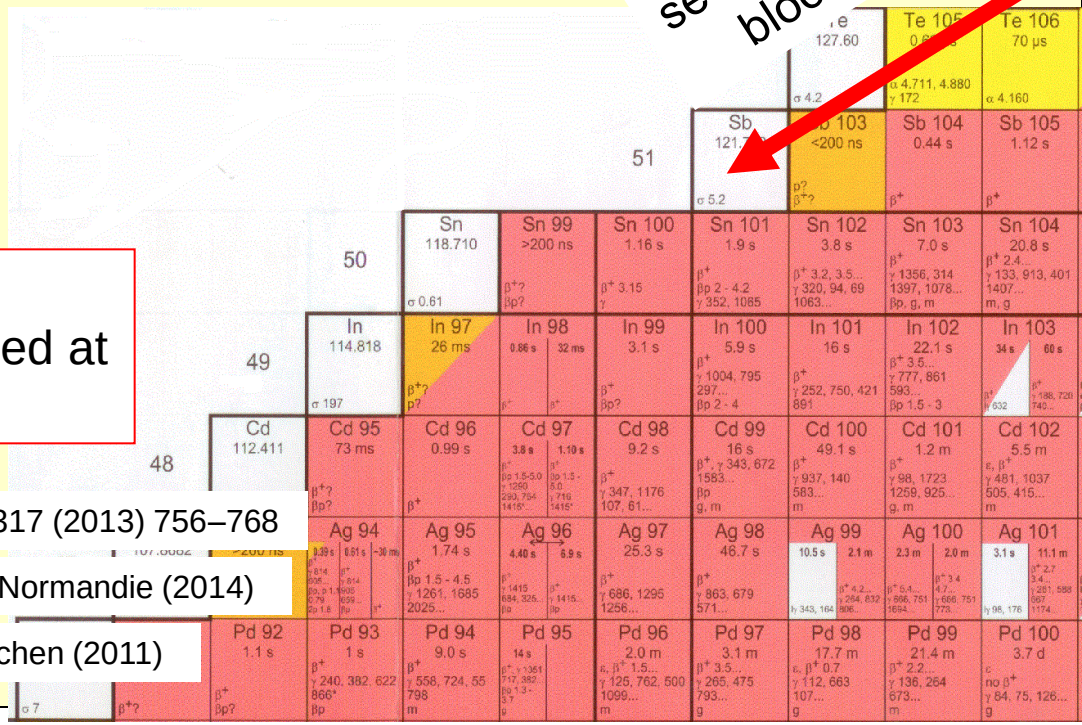
	this work 4 mm (mb)	345MeV, 4 mm [1] (mb)	345MeV, 8 mm [2] (mb)	1GeV, 22 mm [3] (mb)	EPAX 3.01 (mb)
^{100}Sn	~1 ×10^{-9}	7.4 ×10^{-10}	1.5 ×10^{-9}	5.8 ×10^{-9}	5.8 × 10^{-9}

Most of the other nuclei are nicely calculated by EPAX!

Different energies or different processes pronounced at different target thicknesses??

secondary proc. blocked ??



1) H. Suzuki et al. Nucl. Inst. and Meth. in Physics B 317 (2013) 756–768

2) I. Celikovic PhD thesis, Université de Caen Basse-Normandie (2014)

3) K. Straub PhD thesis , Technische Universität München (2011)

^{98}In Decay

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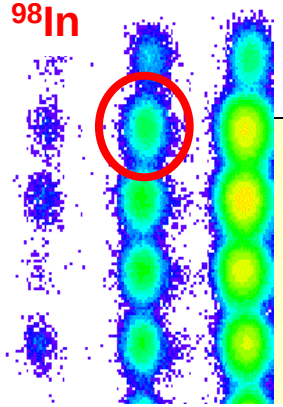
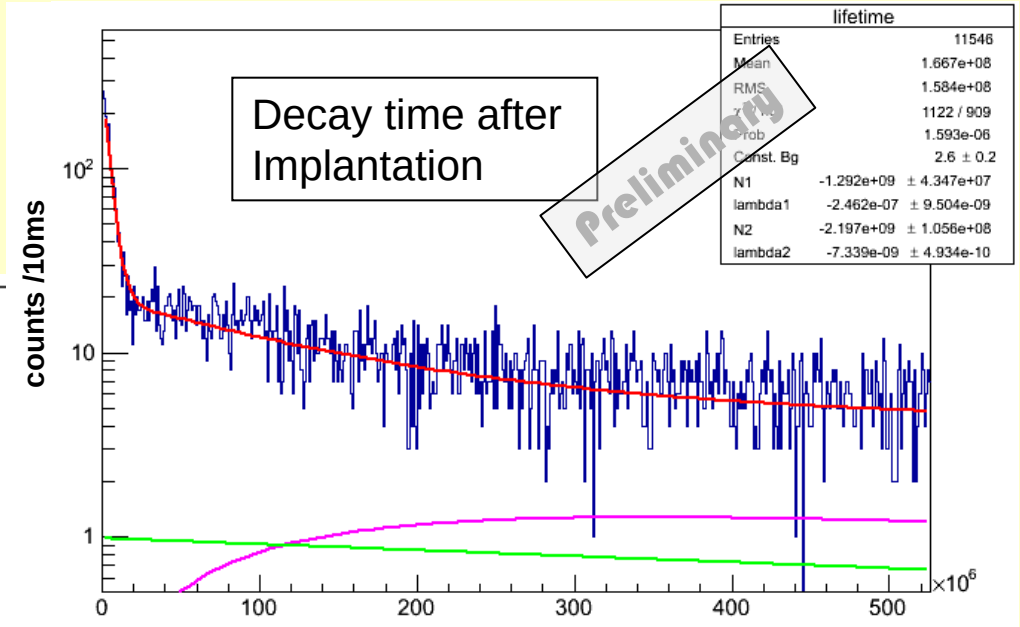
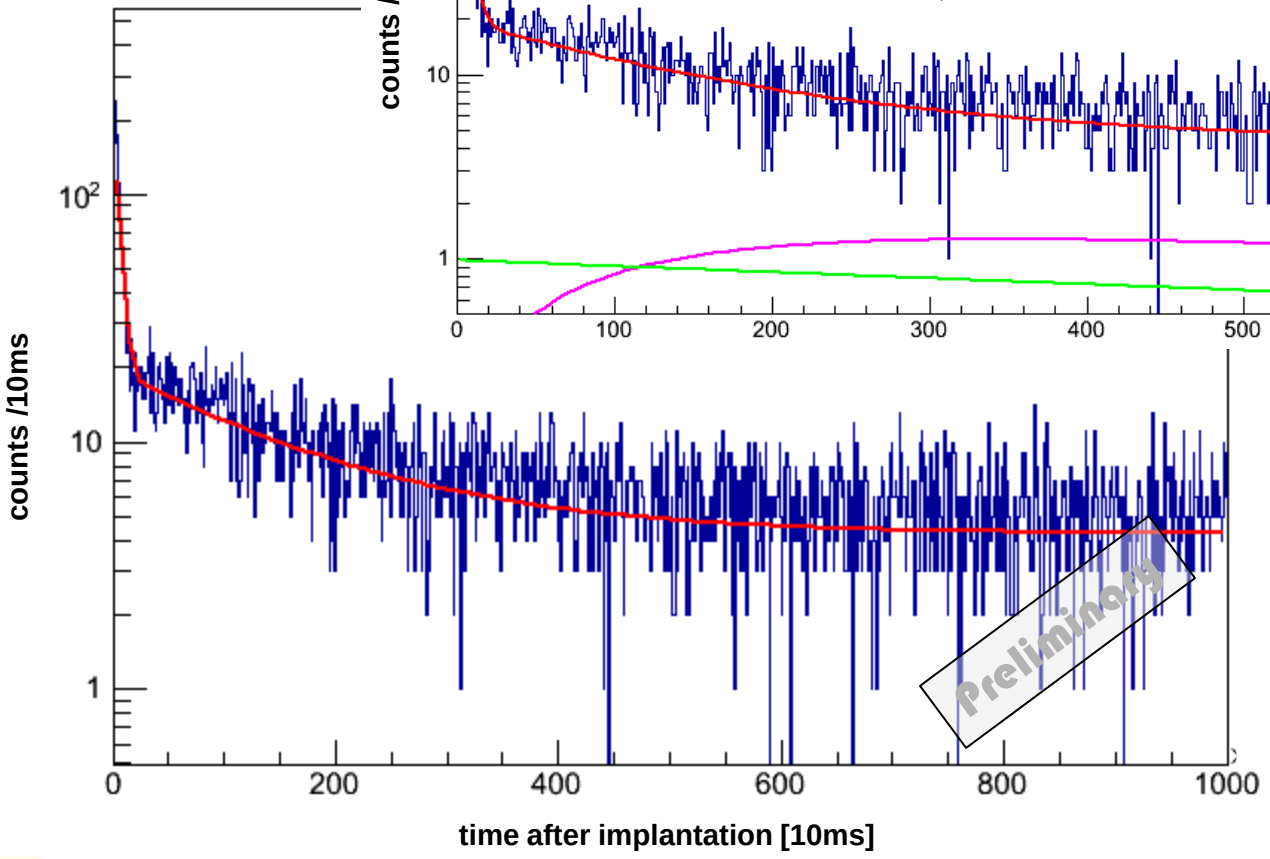
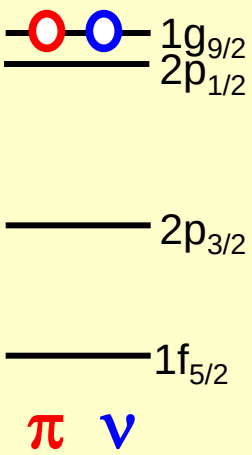






^{100}Sn



$T_{1/2\_long}$ = 0.95(6)(x) s

$T_{1/2\_short}$ = 28(1)(x) ms

P.Kienle et al. Prog. Part. Nucl. Phys. 46, 73 (2001)

D.Bazin et al. PRL 101, 252501 (2008)

^{98}In Fast Component

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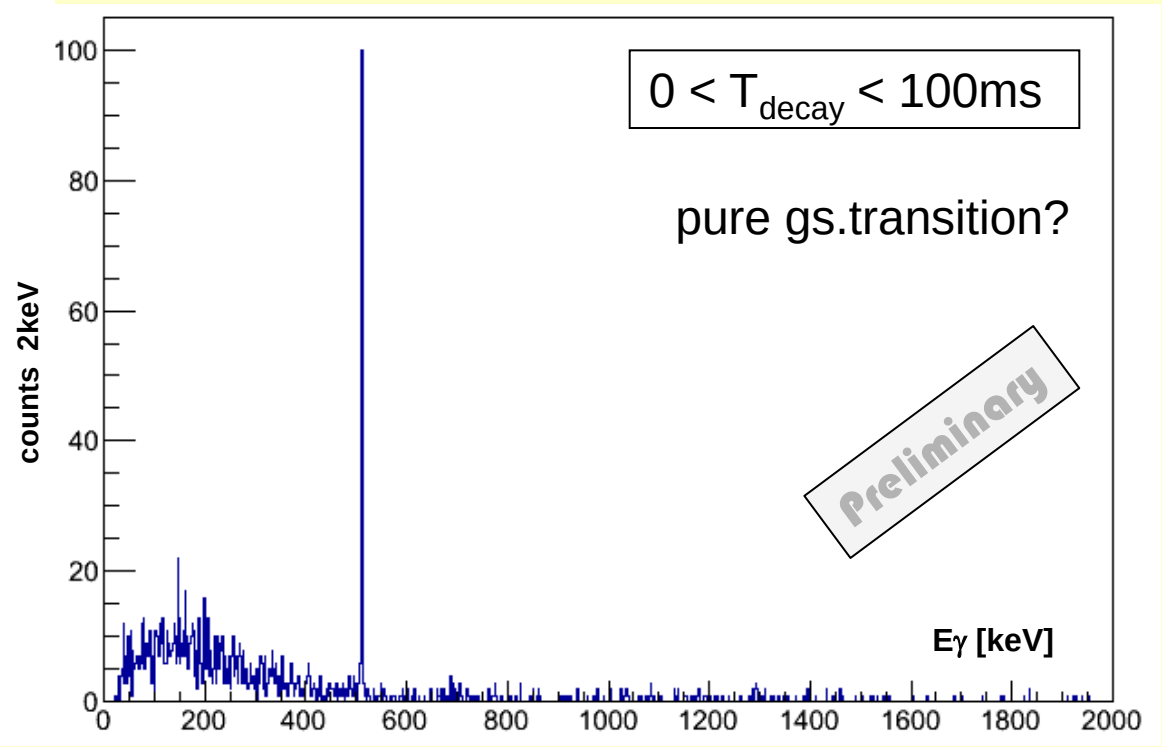
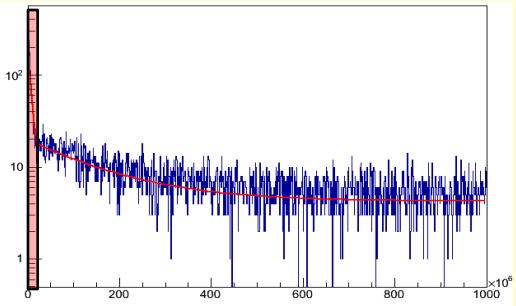
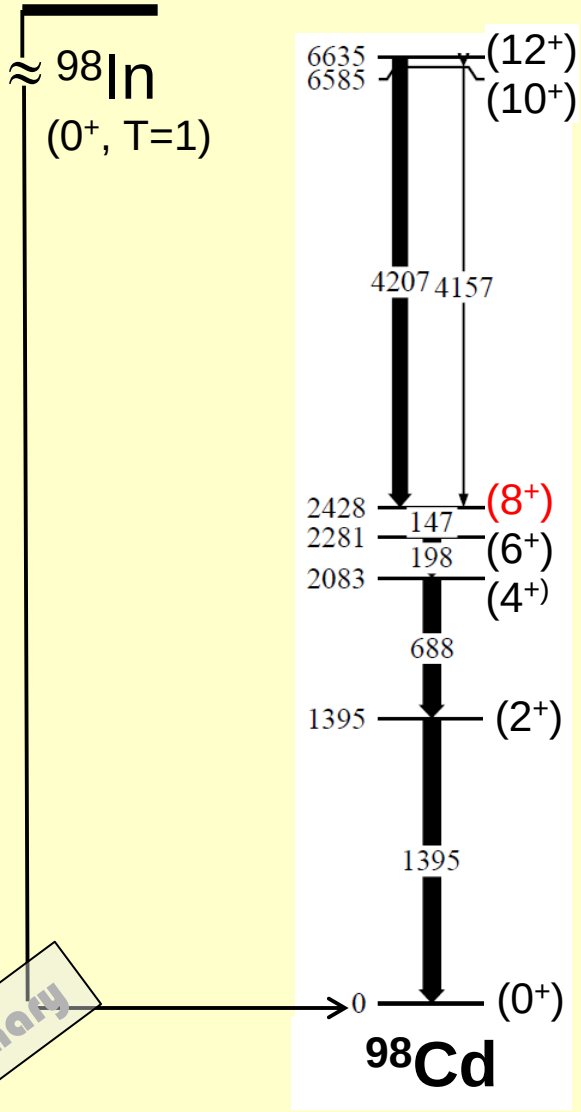




$T_{1/2\_short}$ = 28.6(x) ms

using log(ft) = 3.487
Q_{EC} = 12.53 MeV
from CDE : 13.18 MeV
from AME : 13.74 MeV

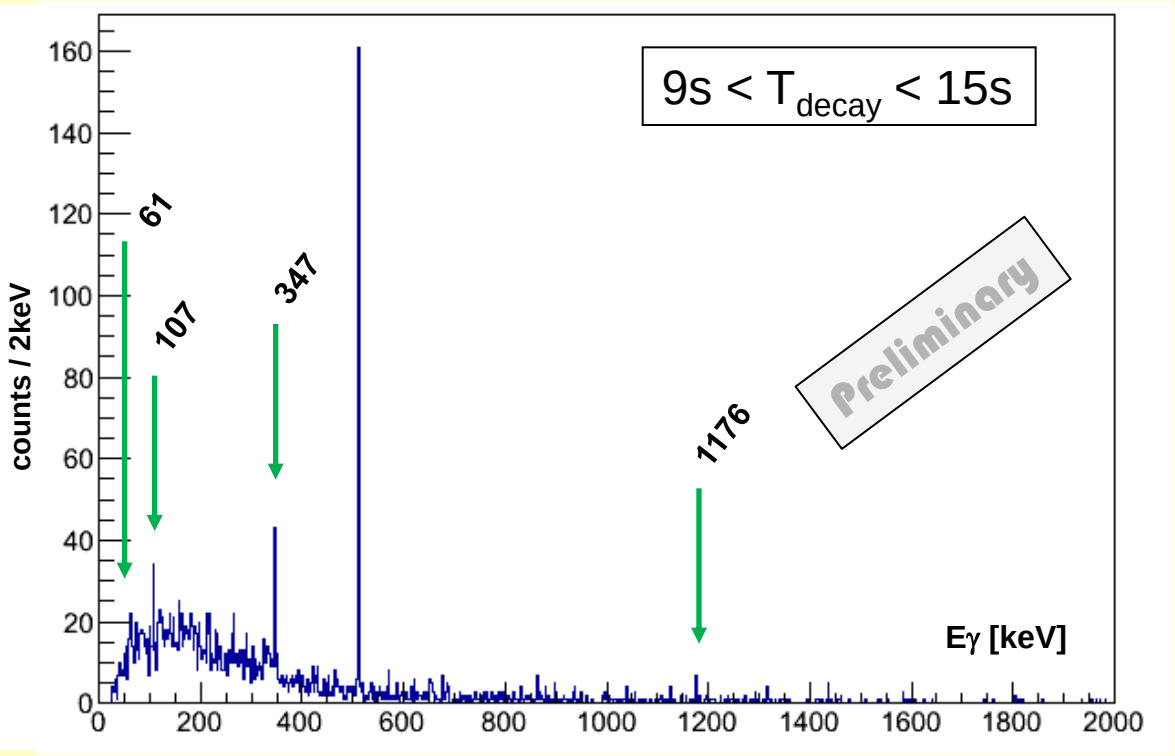
Preliminary



CDE: M.S. Antony el al., Nuc.Data Tables 66 (1997) S Conference June 2014 @ Tokyo

^{98}In Daughter Component

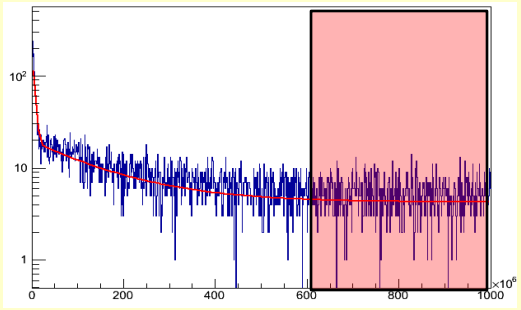
Lehrstuhl E12



$^{98}Cd \rightarrow {}^{98}Ag$

Table 1. Energies, relative intensities, and coincidence relations for γ-rays following the $^{98}Cd \rightarrow {}^{98}Ag$ decay. One I_γ^{rel} unit corresponds to 0.0008 per ^{98}Cd decay

E_γ(keV)	I_γ^{rel}	Coincident lines
60.55(10)	450(20)	XAg, 107, 347, 511, 625, 775, 795, 899, 1098, 1176, 1523
107.28(10)	560(14)	XAg, 61, 347, 511, 625, 775, 795, 899, 1124, 1176
347.18(10)	1000	XAg, 61, 107, 511, 552, 625, 775, 874, 1176, 1346
551.7(3)	43(6)	107, 347, 625
624.9(3)	105(15)	XAg, 61, 107, 347, 511, 552, 899
775.6(4)	60(15)	XAg, 61, 107, 347, 511, 874
794.7(4)	62(12)	60, 107, 347, 511, 899
874.5(5)	43(8)	347
898.5(3)	160(30)	XAg, 61, 107, 511, 625, 795, 1098
1098(1)	30	
1124(1)	27(9)	
1176.1(2)	850(30)	XAg, 61, 107, 347, 511
1346(1)	20(3)	
1523.0(5)	44(10)	61, 107

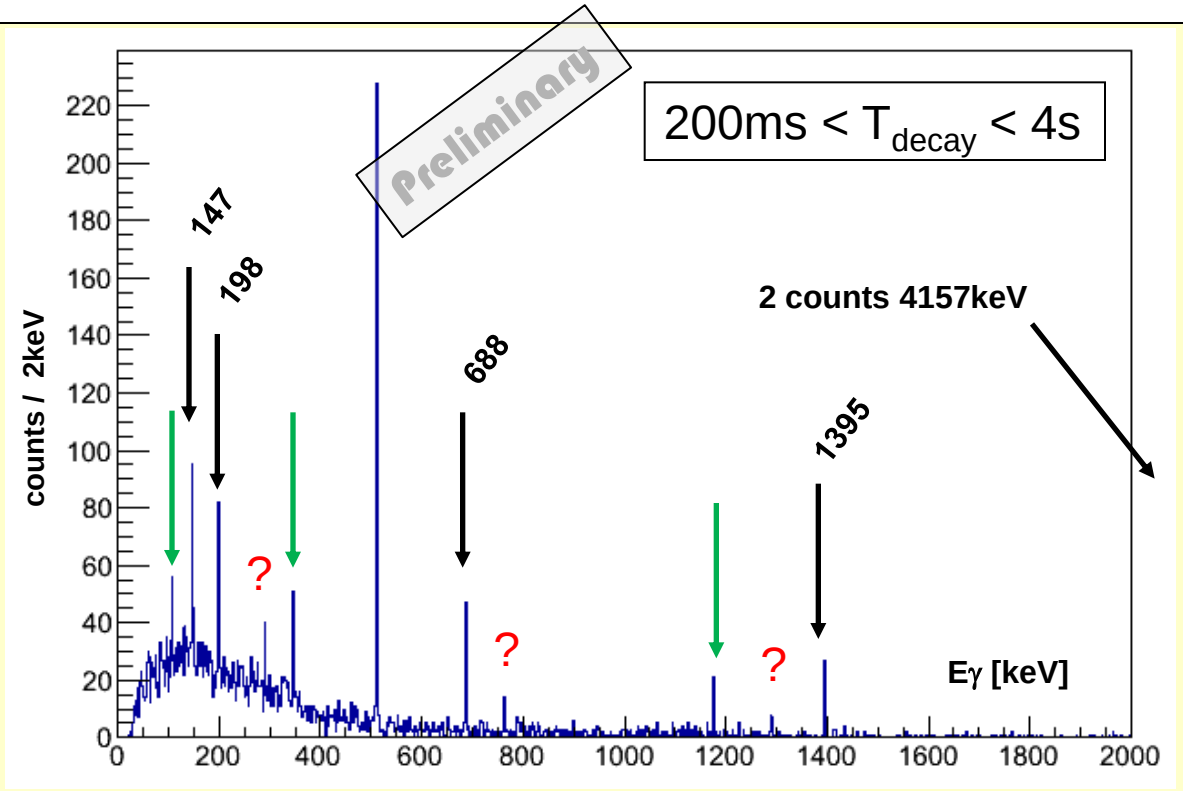


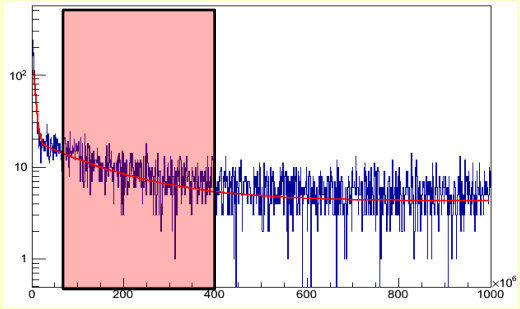
$T_{1/2} = 9.2s$

A. Płochocki et al. Zeitschrift für Physik A (1992), 342,1, pp 43-51

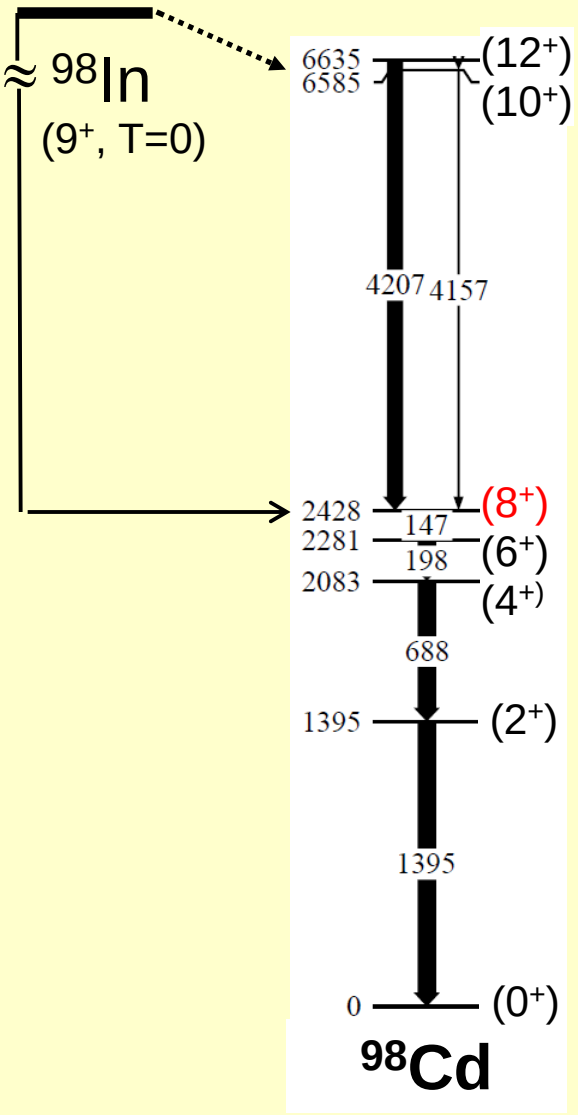
^{98}In Slow Component

Lehrstuhl E12

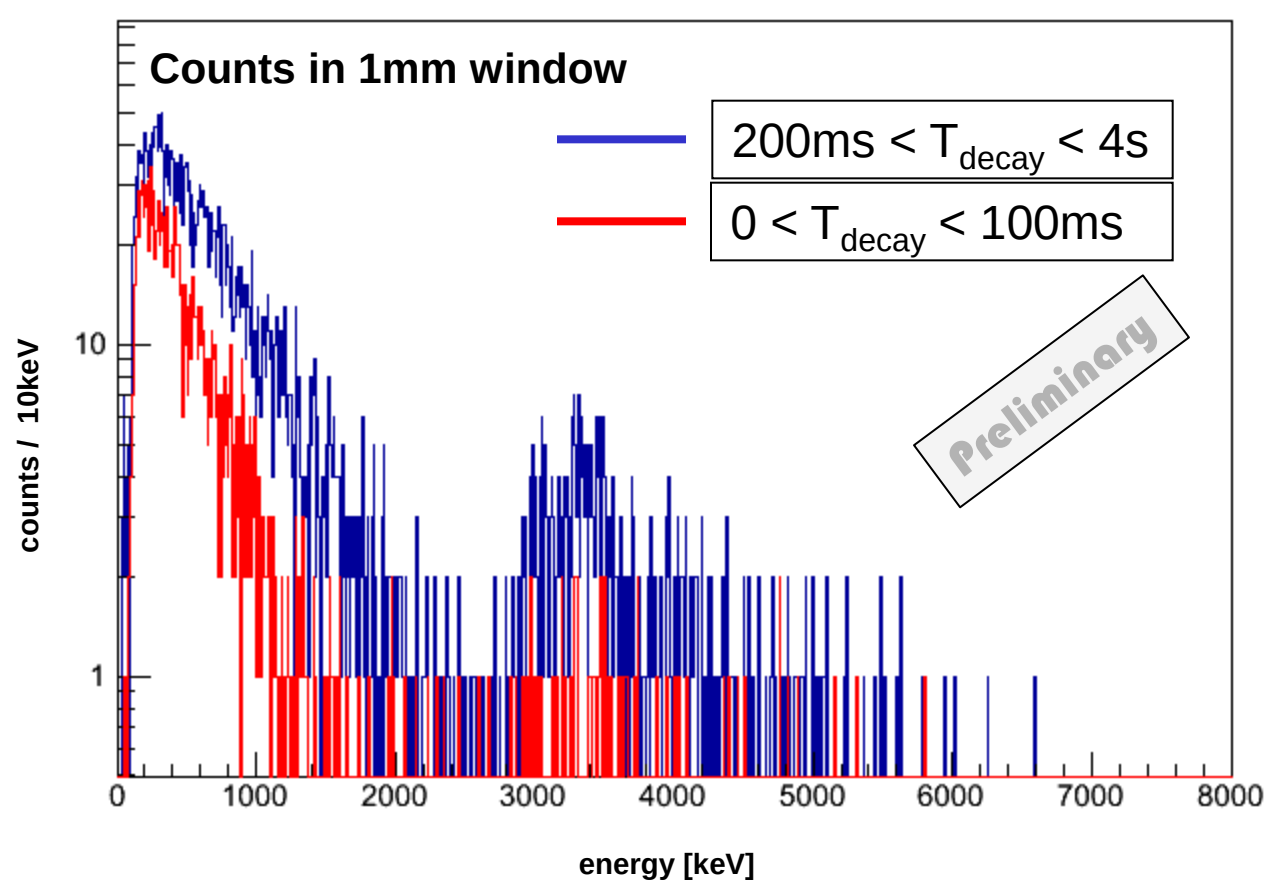




$T_{1/2\_long}$ = 0.95(6)(x) s

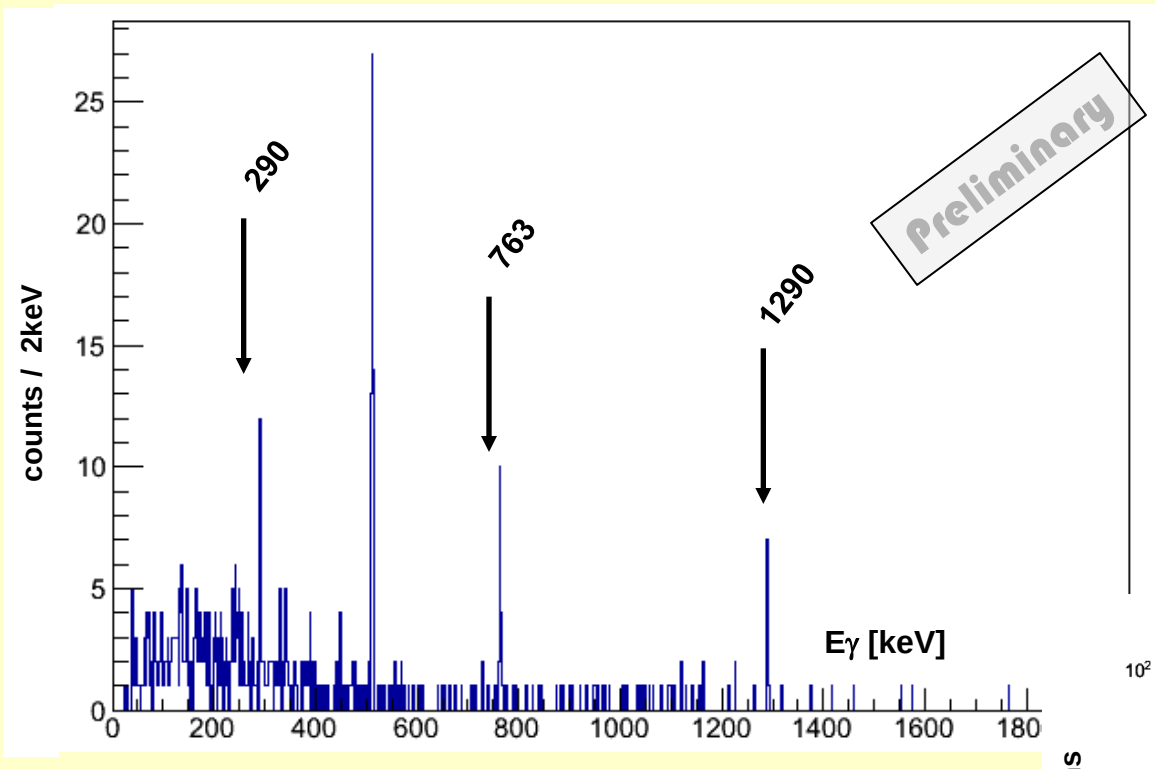


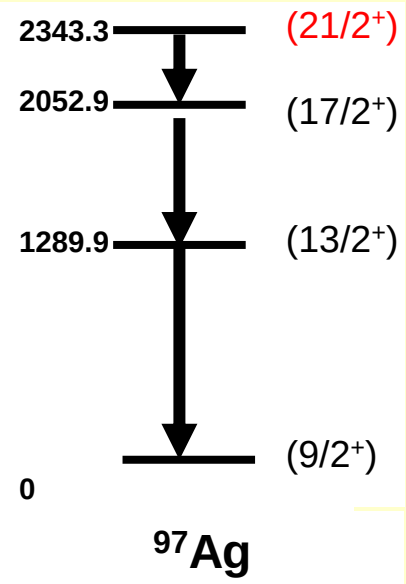
^{98}In Silicon Energy

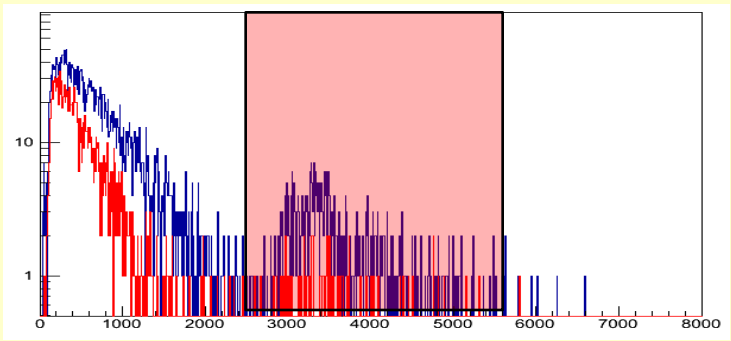


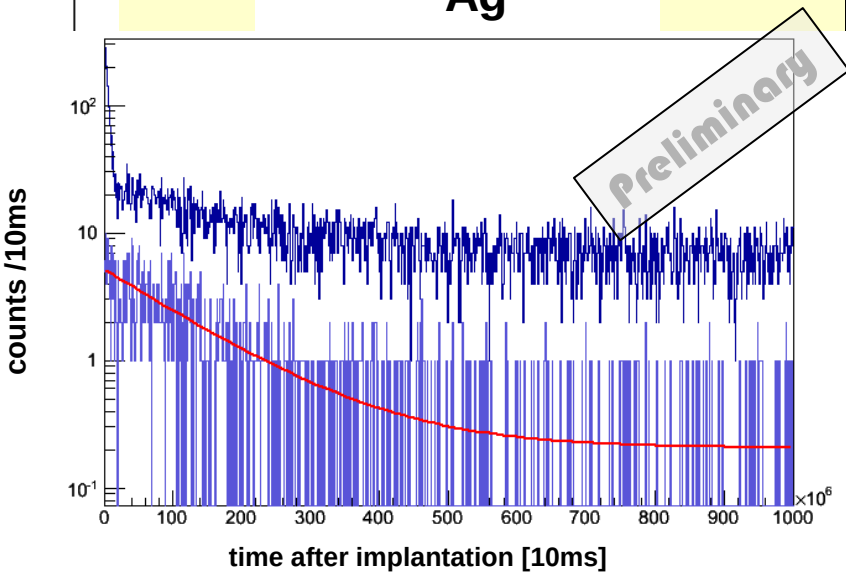
see also: G. Lorusso et al., Phys. Rev. C 86 (2012)

^{98}In βp - decay









^{98}In Ground State

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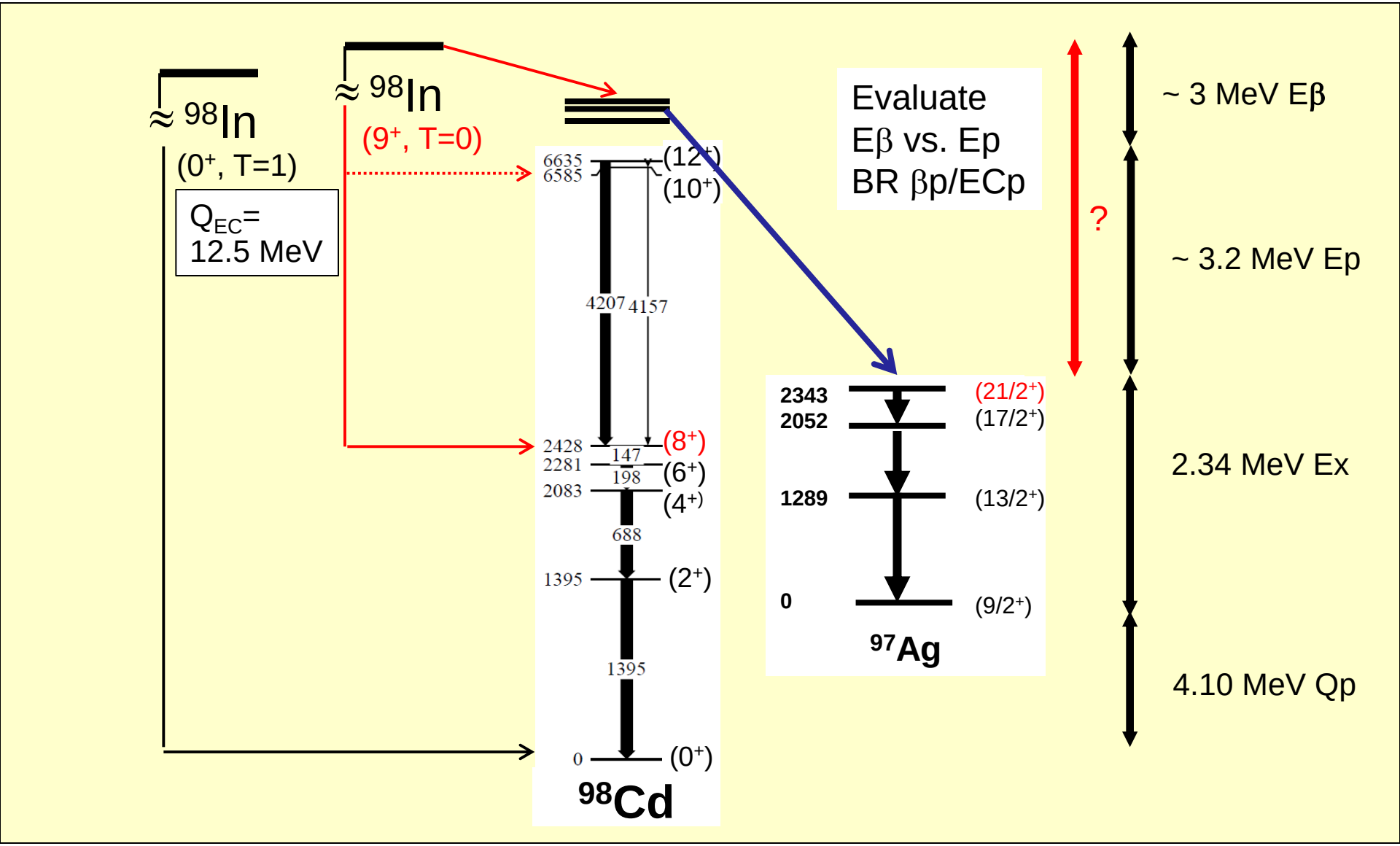


N = Z-1 Nuclei

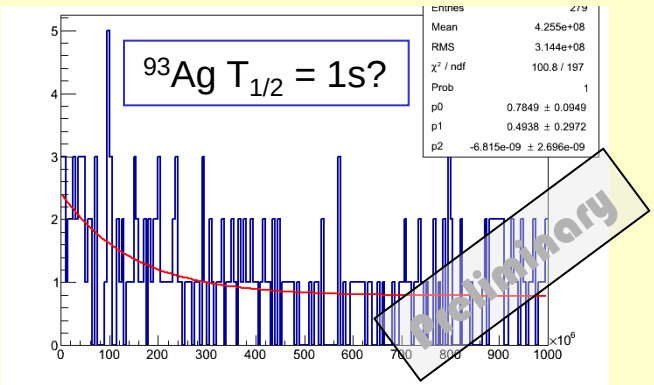
Lehrstuhl E12

New or significantly improved $T_{1/2}$

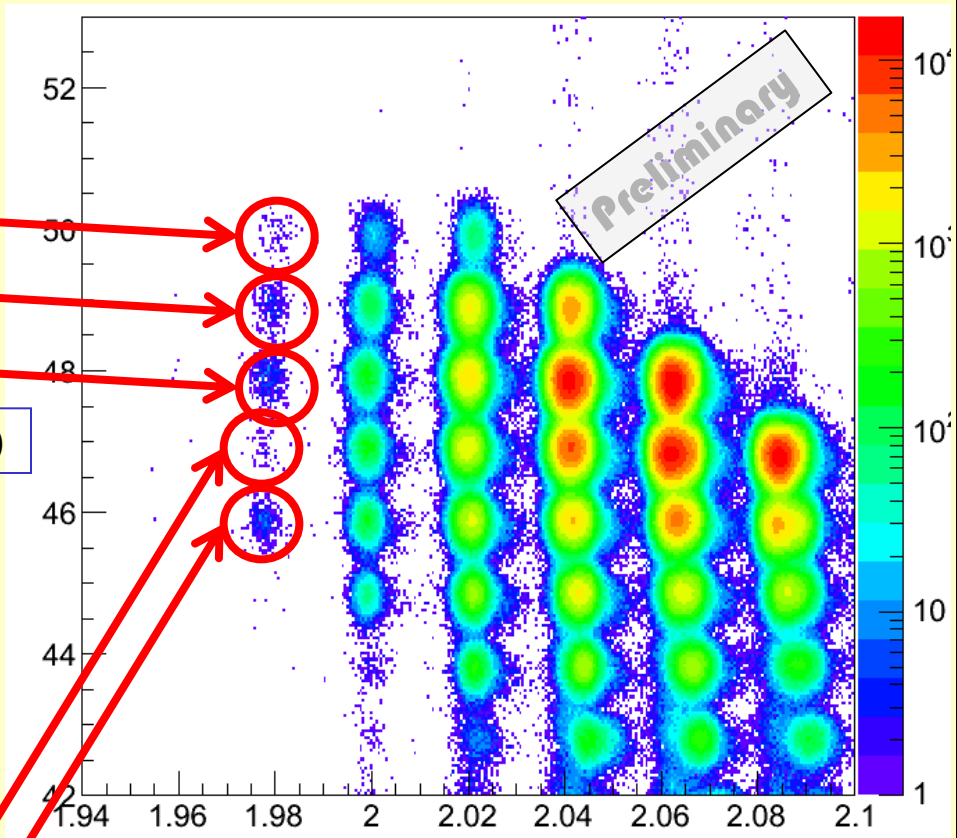
Preliminary

$T_{1/2}$ = 25(x) ms,	^{99}Sn
$T_{1/2}$ = 31(x) ms,	^{97}In
$T_{1/2}$ = 26(x) ms, 3% βp? ,	^{95}Cd

Straub et al. GSI report 2010, 57ms (2 counts)



$T_{1/2}$ = 0 (x) ms,	^{93}Ag
$T_{1/2}$ = 32(x) ms,	^{91}Pd



^{93}Ag : $T_{1/2}$ = 300(-200 +600) ns
L=4 , g9/2 proton, Qp =1050(100) keV
AME12: 1510(710)keV

Delion et al., PRL96, 072501 (2006)

Most Exotic Nuclei

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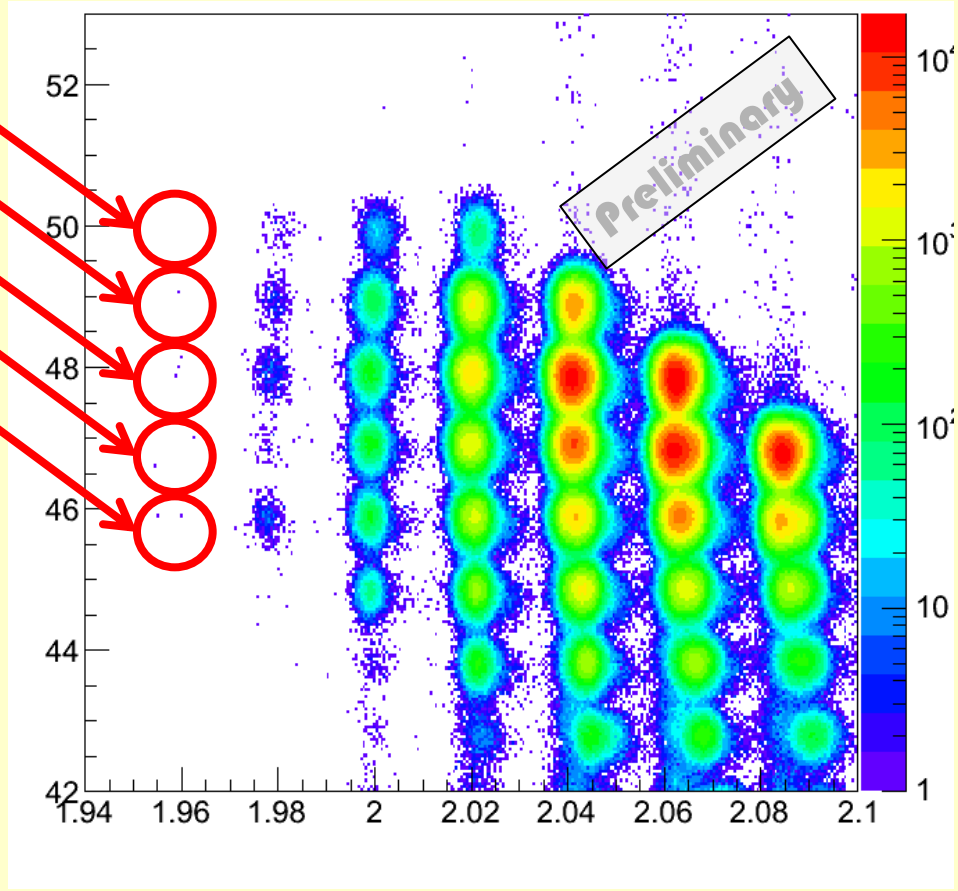
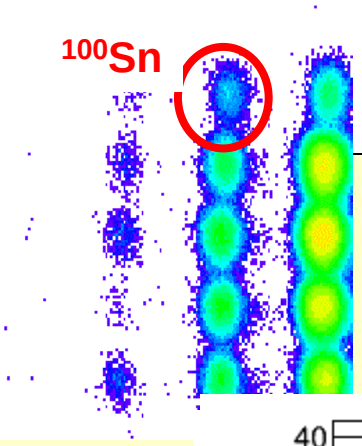
Preliminary

decays	identified	Isotope
gone	1	^{98}Sn
1 count , 16ms	2	^{96}In
3 counts, daughter?	6	^{94}Cd
1 count , 1.5ms ?	9	^{92}Ag
2 counts, 5ms ,15ms	4	^{90}Pd



All counts have to be checked for last implantation, 1st and 2nd decay PDFs

BG =1 / 20s



Decay of ^{100}Sn

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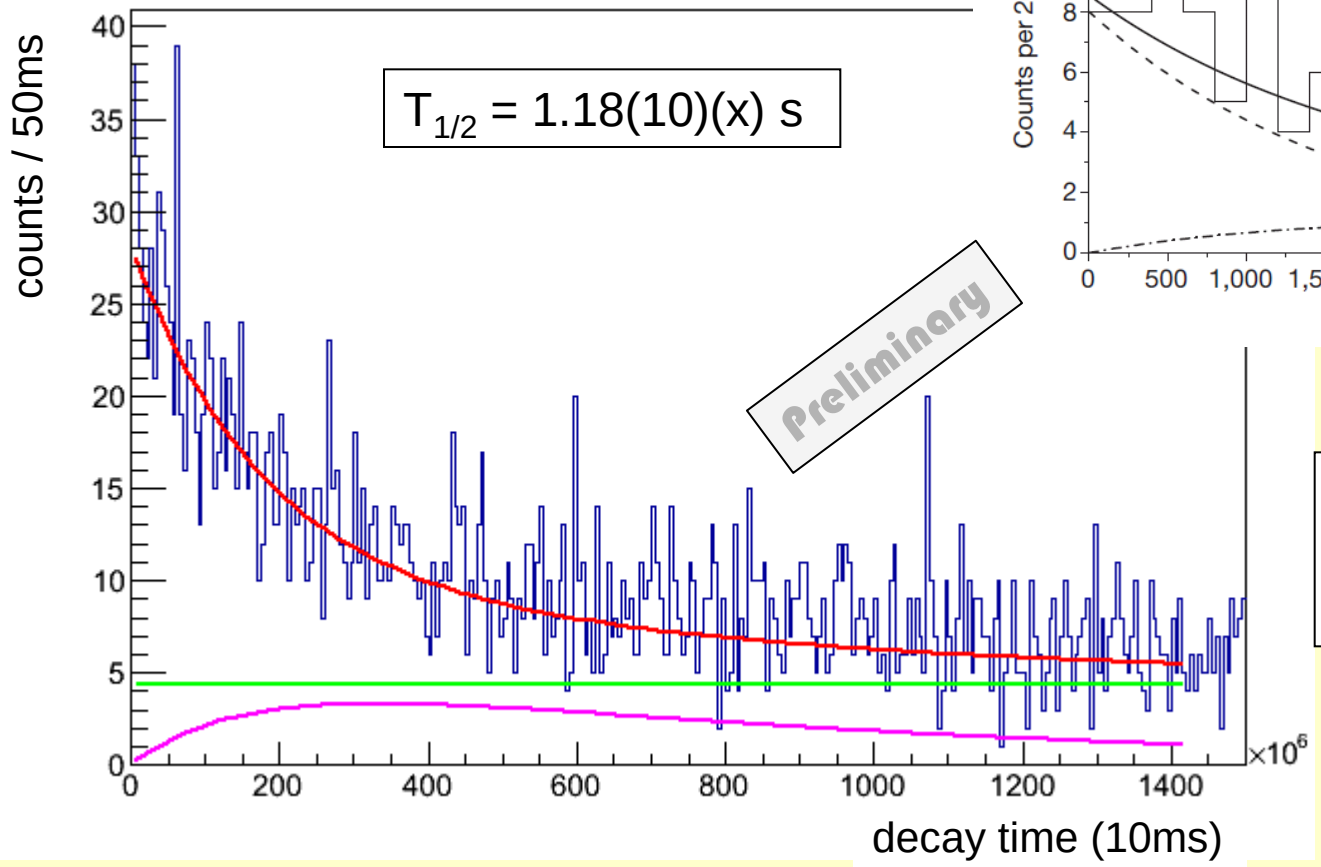
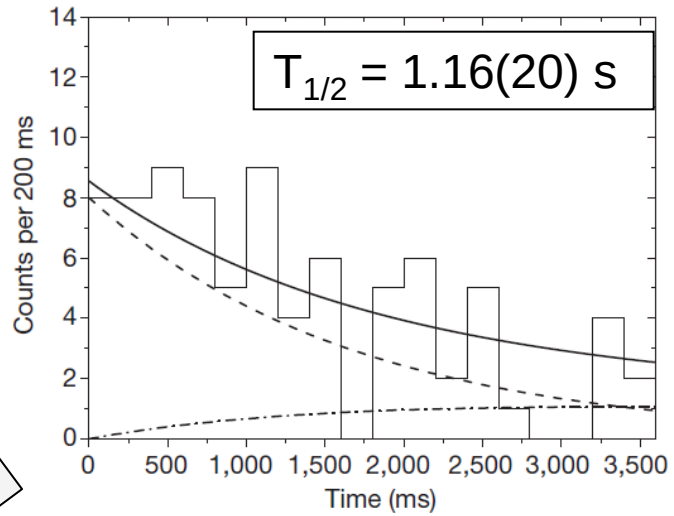
(NOT FULL STATISTICS)



C. Hinke et at., Nature 486, 341–345 (2012)



check selection according to PDFs

BG =1 / 20s

^{100}Sn Delayed Gammas

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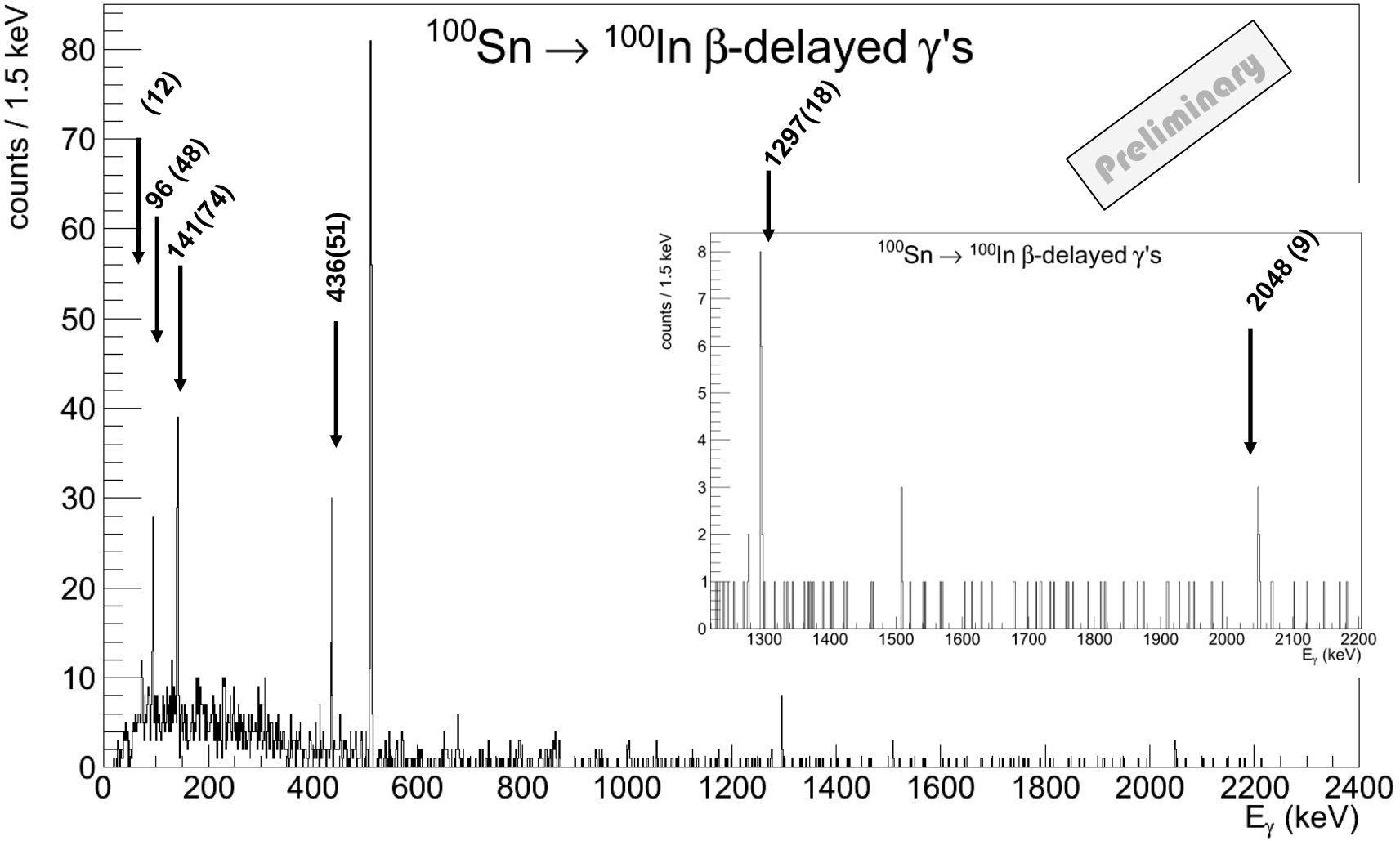
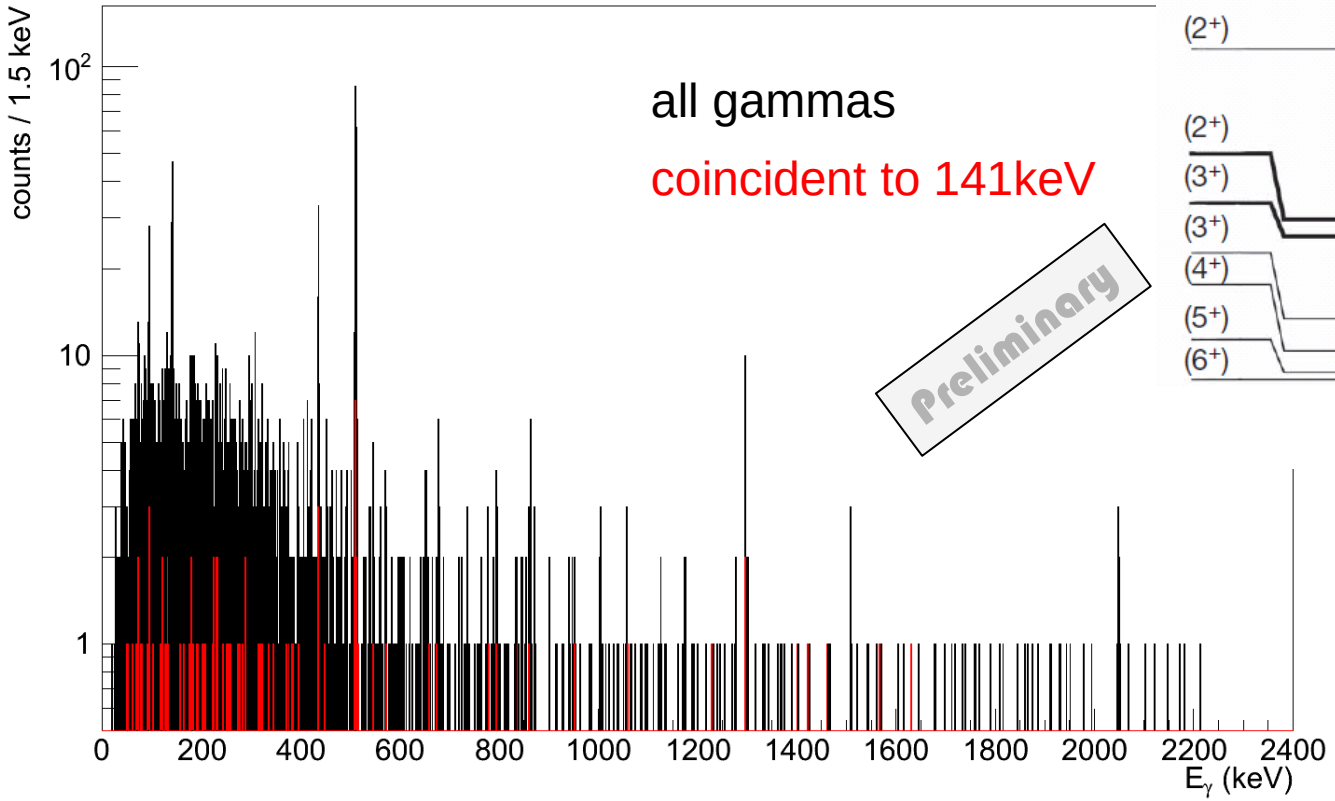
1st decay within 4 s

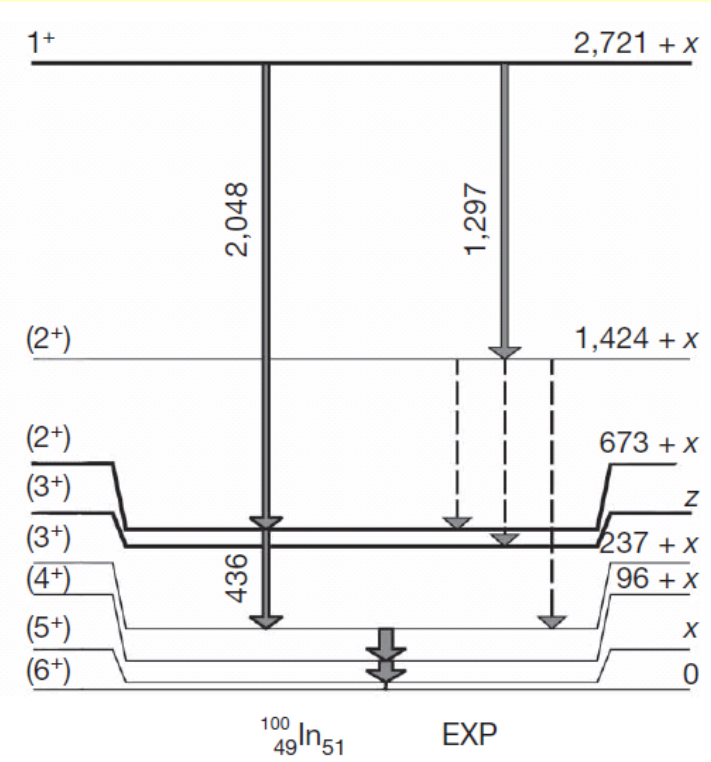


100Sn Decay Gamma Rays

Lehrstuhl E12

coincidences 96 – 141 – 436 – 1296
no coinc. 2048 – (141 || 436 ||1296)
ongoing background studies





C. Hinke et at., Nature 486, 341–345 (2012)

Gamma Efficiency from ^{98}Cd Isomer

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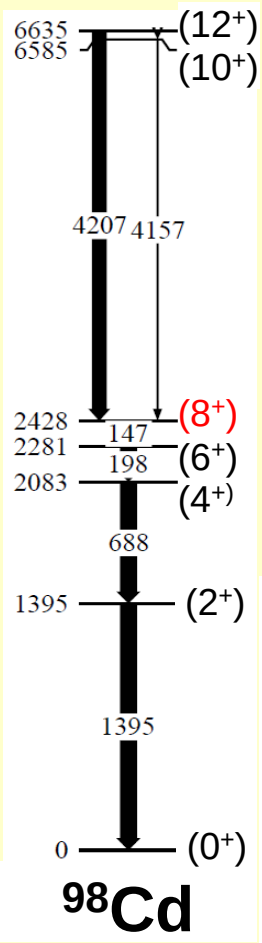
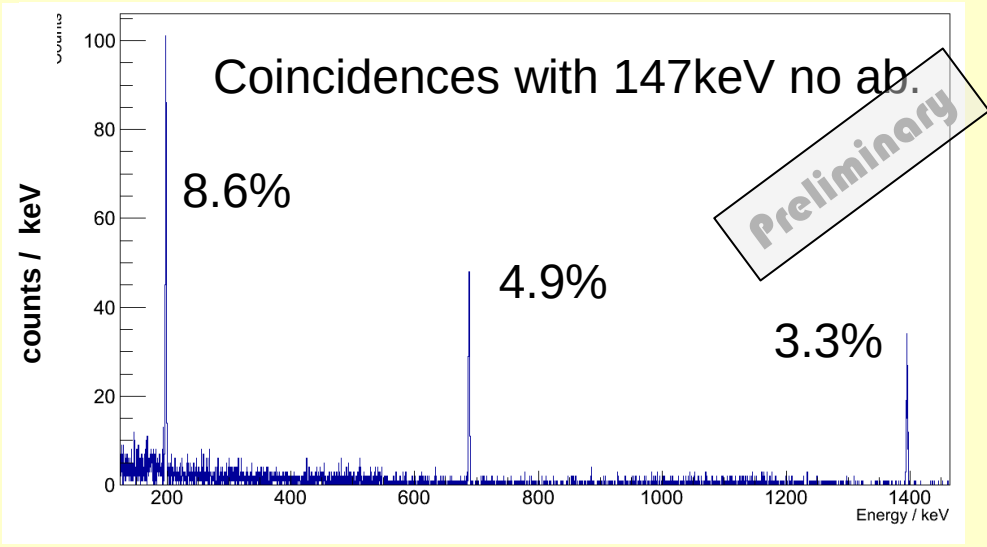
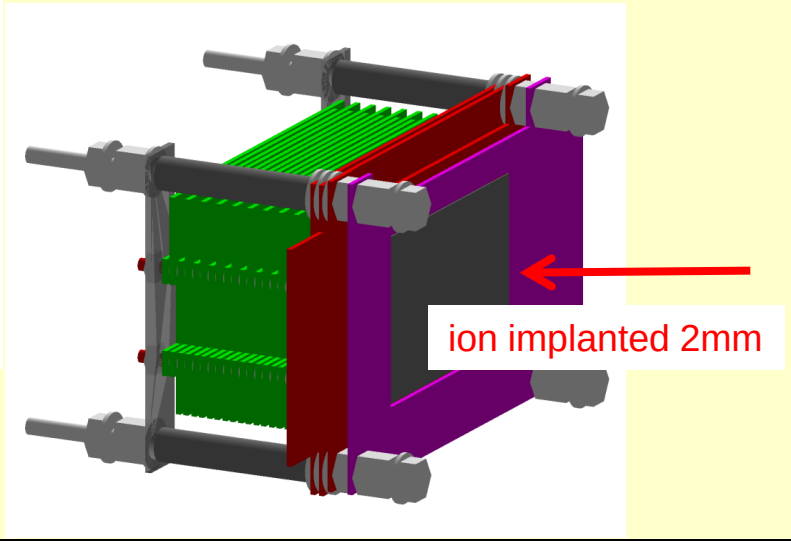
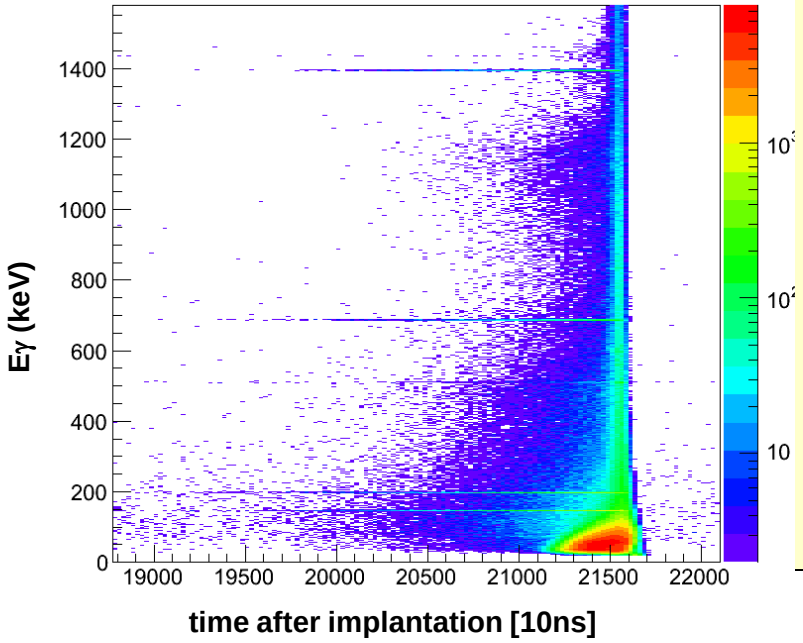


about 10000 counts
in the strongest line
- relative calibration
- absolute calibration





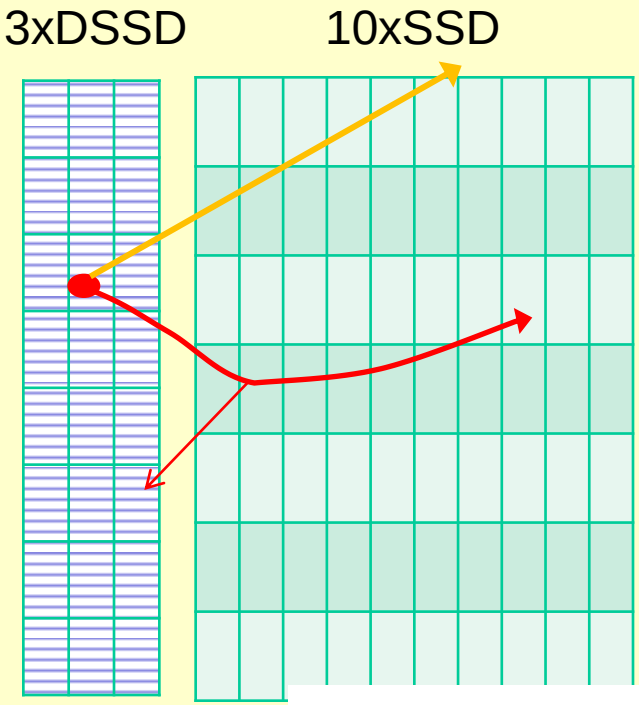


The Challenge

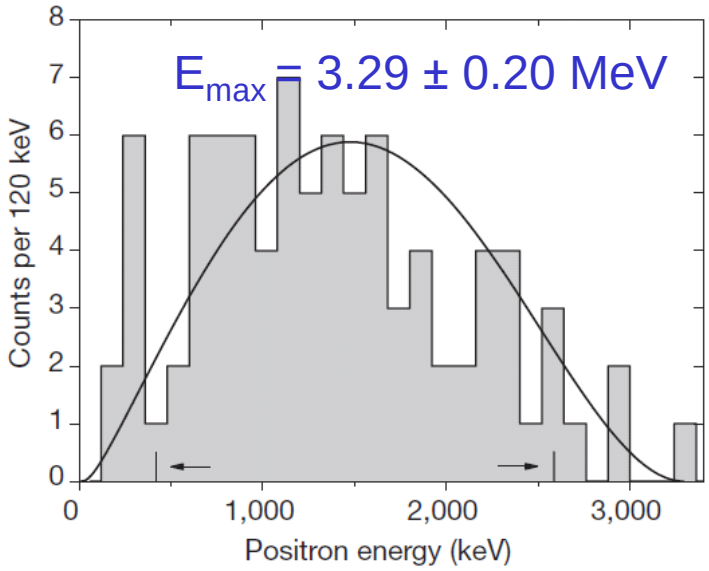
$$B_{GT}^{\exp} = \frac{6142.8s}{(g_A / g_V)^2 \, ft}$$

$\sim Q_\beta^5$ $T_{1/2}$

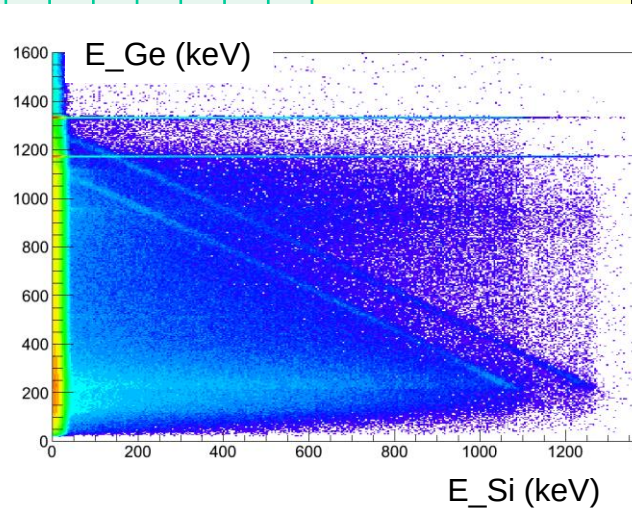
$$B_{GT}^{\exp}\left(1_1^+\right) = 9.1^{+2.6}_{-3.0}$$



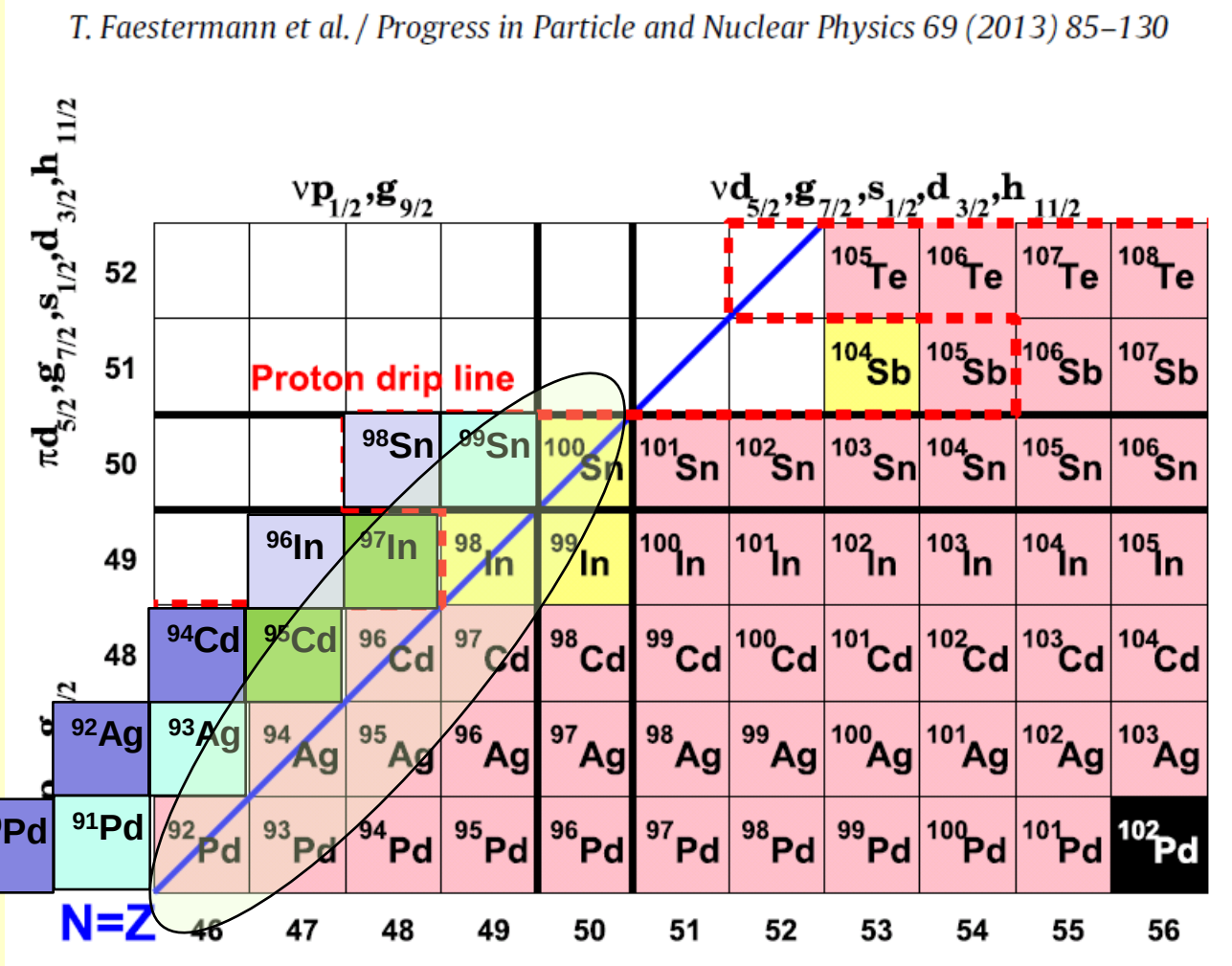
C. Hinke et al., Nature 486, 341–345 (2012)



A small calibration error propagates into a large difference in B_{GT}



Conclusion



List of achievements

- **First evidence**
- **Discovery**
- **new half live**
- **precise half live**
- **spectroscopy**

ongoing
analysis
at several places

RIBF009 Experiment

Lehrstuhl E12

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

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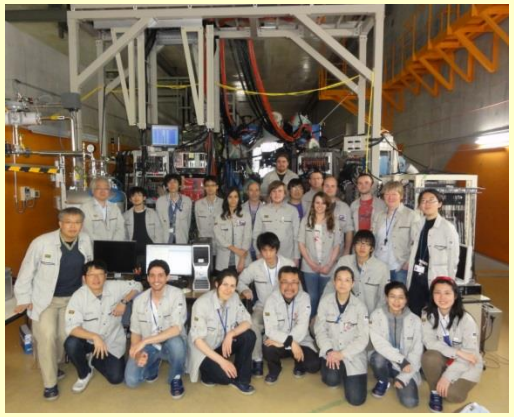
EURICA Collaboration and Support

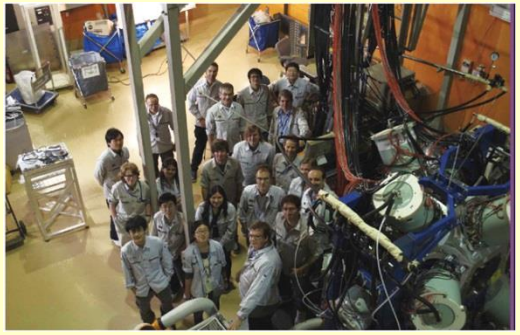
Lehrstuhl E12

2012 Nov.-Dec.

2013 May



2012 June



Collaboration:
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