^{100}Sn Results

not only from RISING

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TU München

for the S330 and
RISING collaboration

Lehrstuhl E12

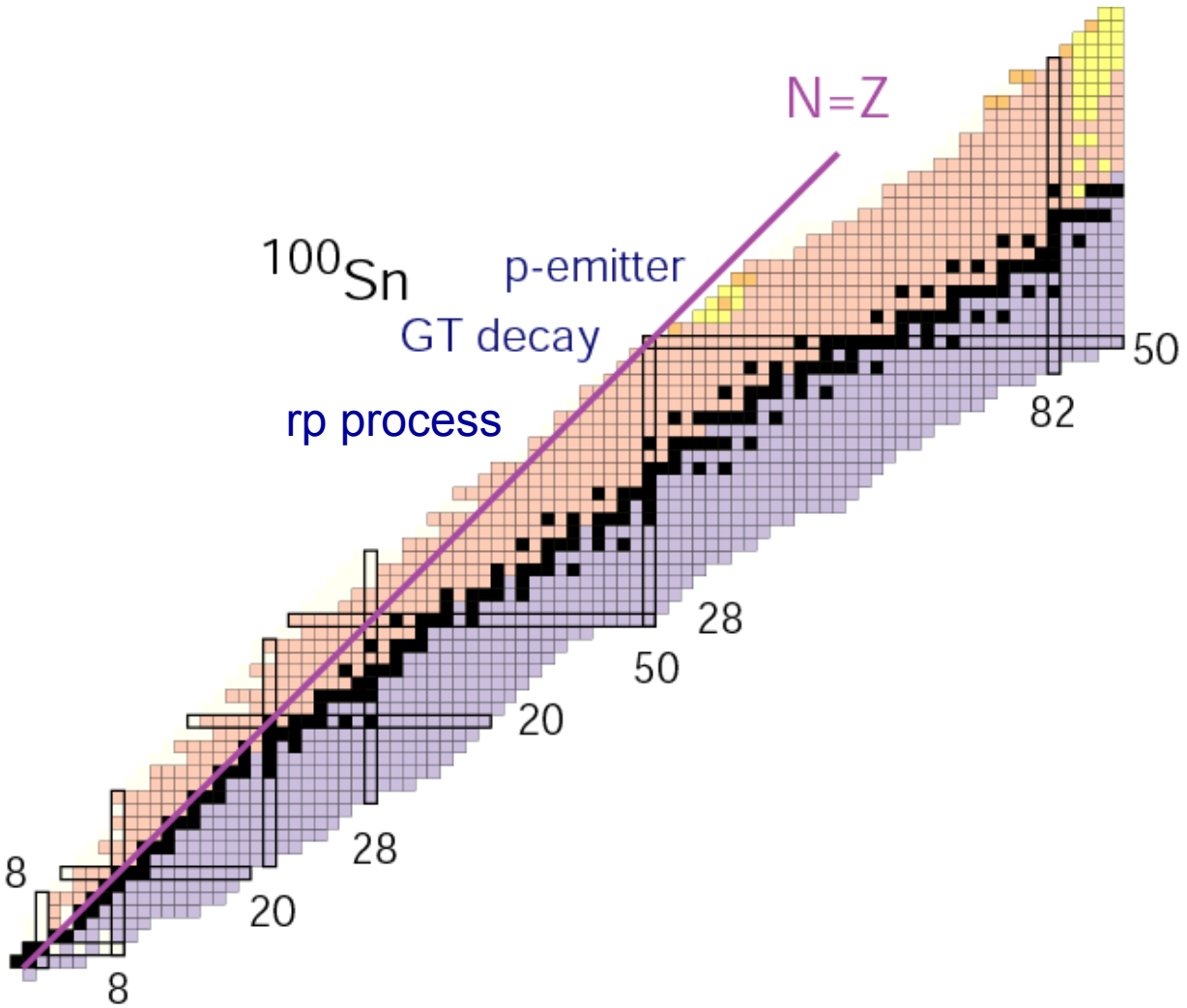
RISING

Excellence Cluster Universe

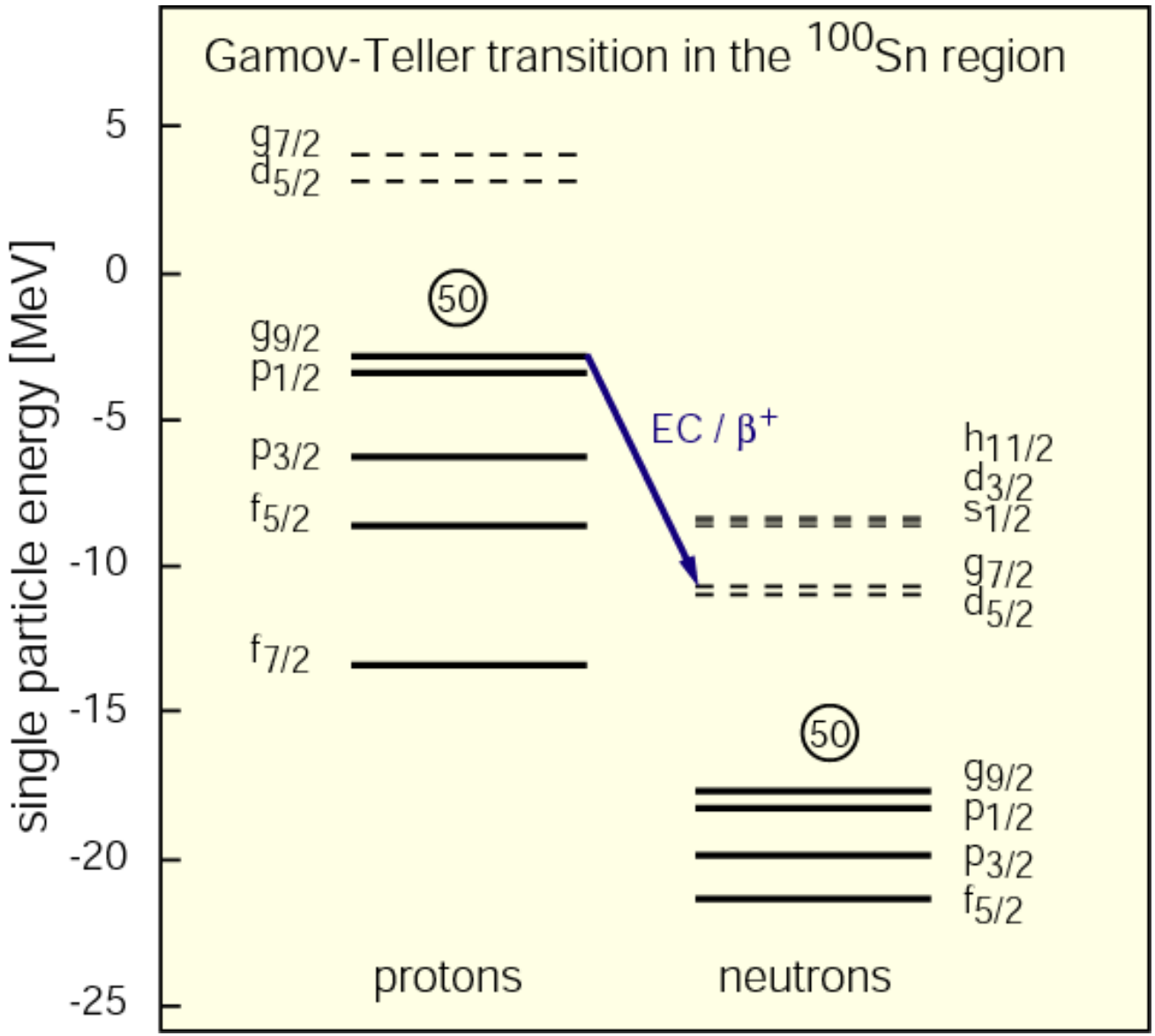
S330

^{100}Sn: Gamow-Teller Strength in its Decay Search for its Isomer Particle Stability of Neighbours

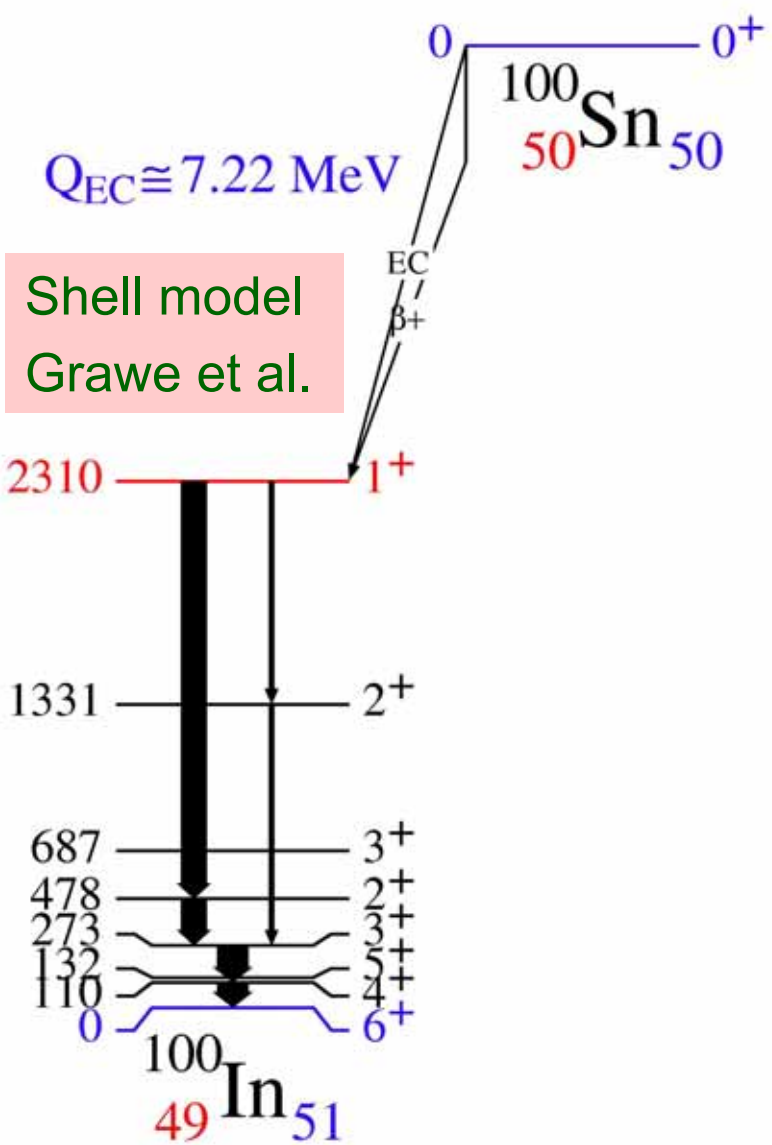
TUM
GSI
Edinburgh
Ankara
Belgrade
Bratislava
GANIL
Groningen
Köln
Krakow
MSU
RIKEN
Surrey
Uppsala
Warsaw
+
RISING



Shell Model Orbitals



^{100}Sn



GT-strength is unique tool to study wave fct.

pure spin-flip transition
$0^+ \Rightarrow (\pi g_{9/2}^{-1}\, \nu g_{7/2})1^+$

large decay energy
=> most of GT strength in β-decay window

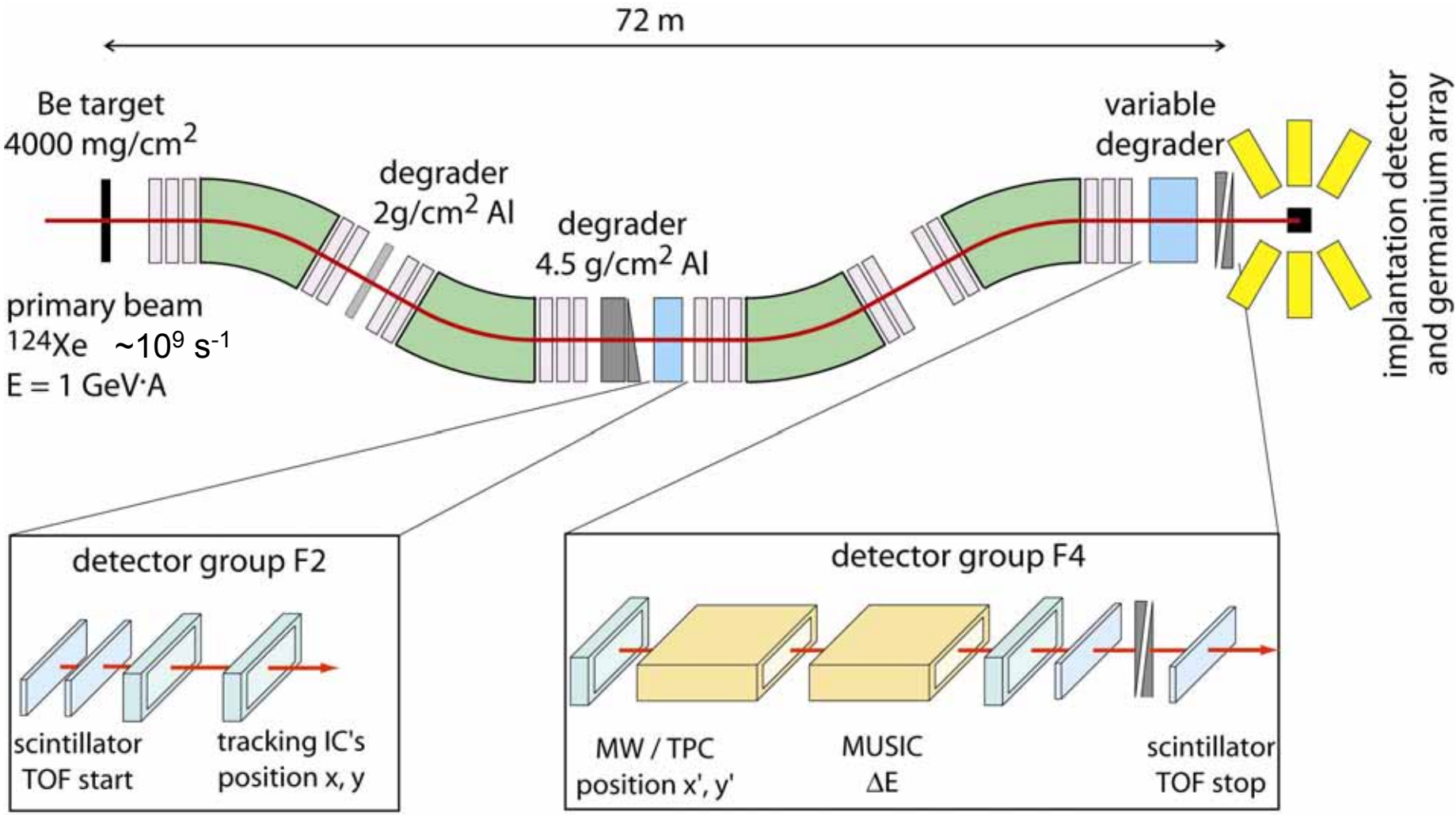
measure:
$T_{1/2}$
β-endpoint energy
(branching)
=> GT-strength

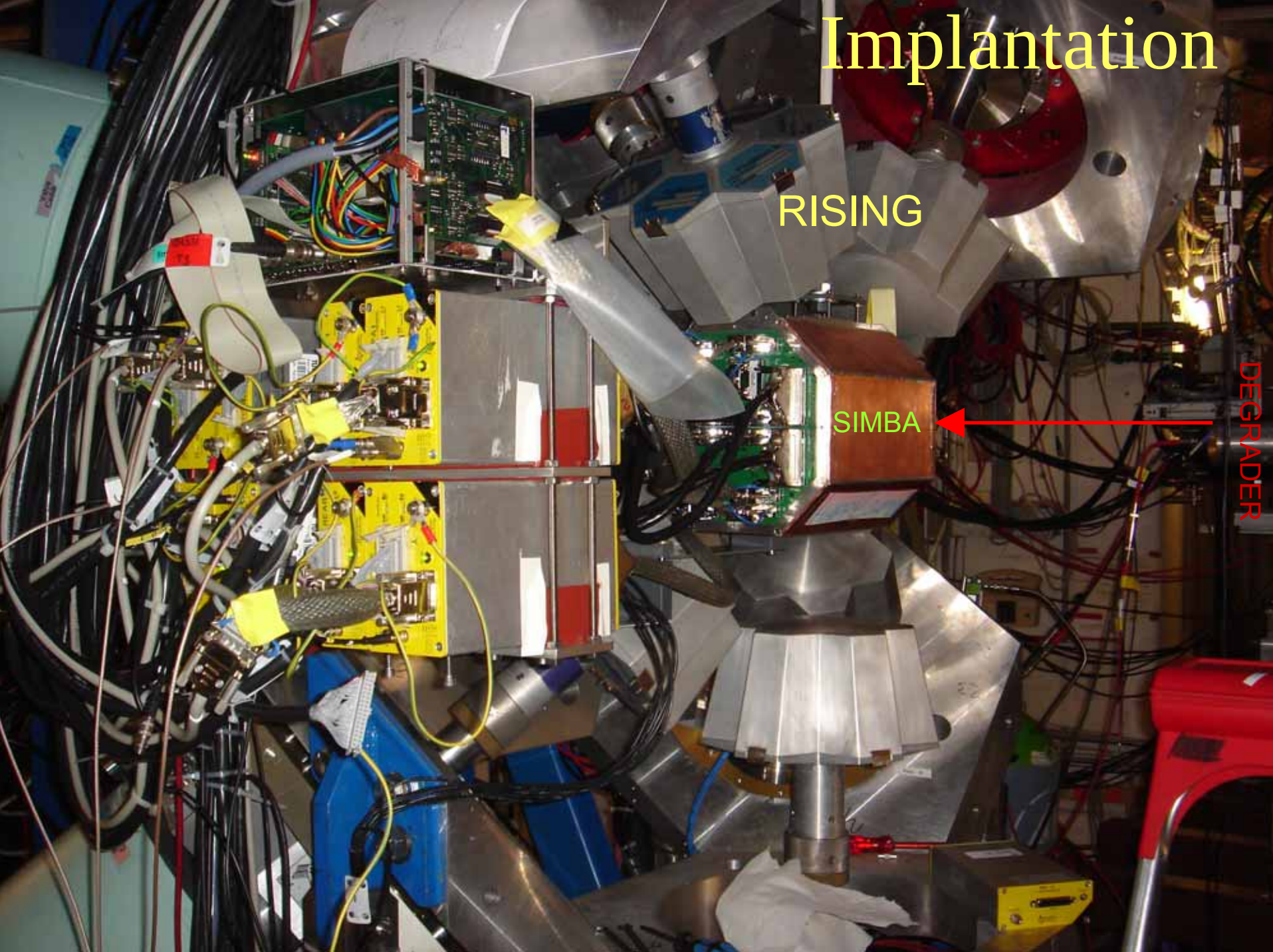
^{100}Sn history

year	where	production	events	quantity		
1994	GSI	fragm. ^{124}Xe	7	$T_{1/2}$	E(β)	E(γ)
1994	GANIL	fragm. ^{112}Sn	11		ident.	
1996	GANIL	fusion	11		Δm	
1998	GSI	fragm. ^{112}Sn	1	$T_{1/2}$	E(β)	E(γ)
2007	MSU	fragm. ^{112}Sn	14	$T_{1/2}$		
2008	GSI	fragm. ^{124}Xe	259	$T_{1/2}$	E(β)	E(γ)

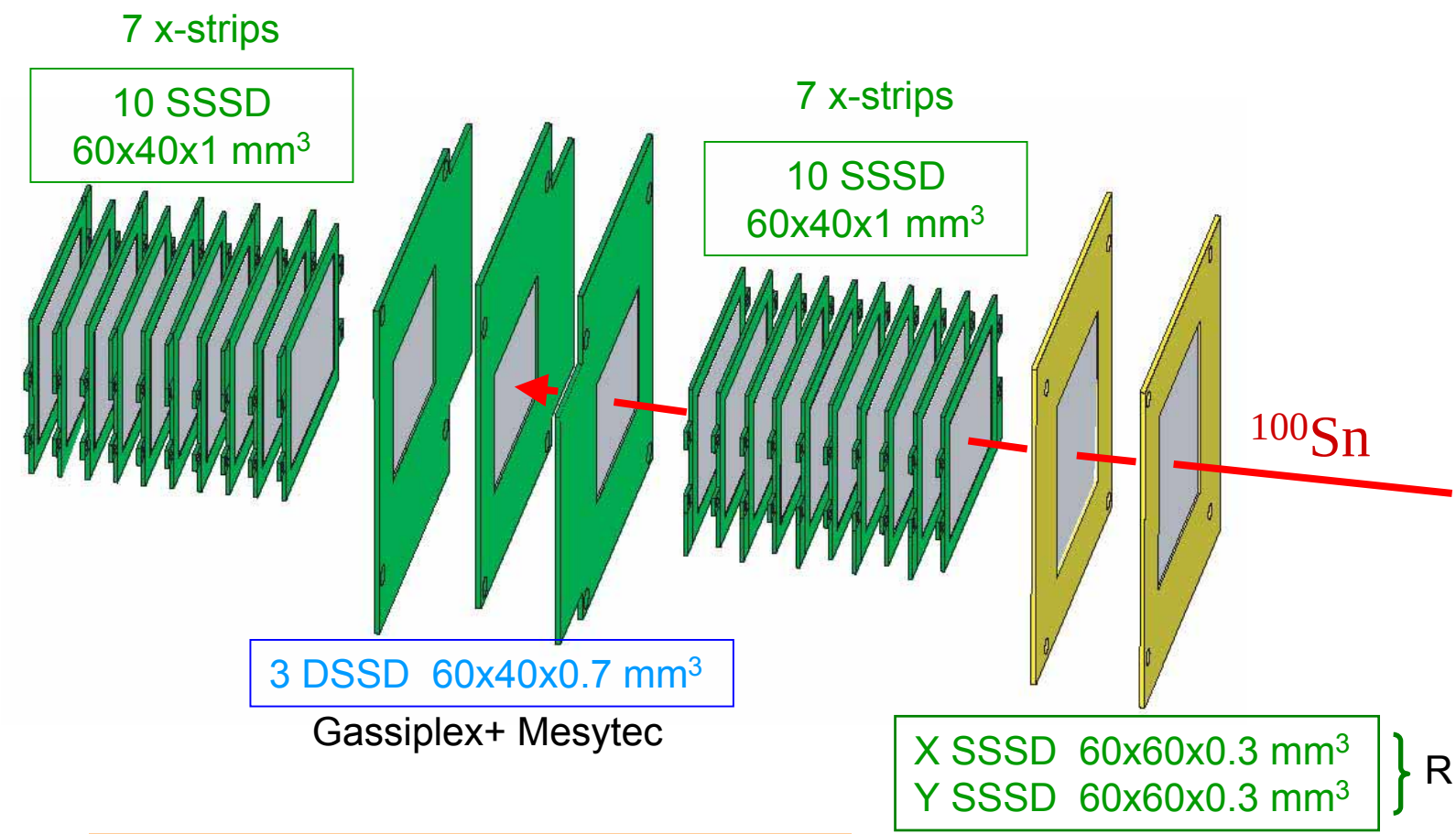
A Complete Setup?

the FRagment Separator (FRS)



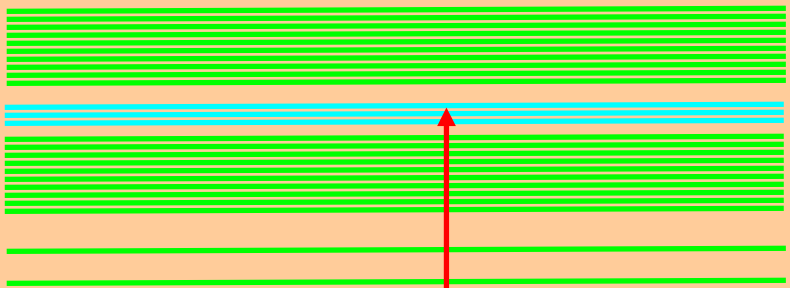

Implantation
RISING
SIMBA
DEGRADER

Silicon Implantation Detector and Beta Absorber SIMBA

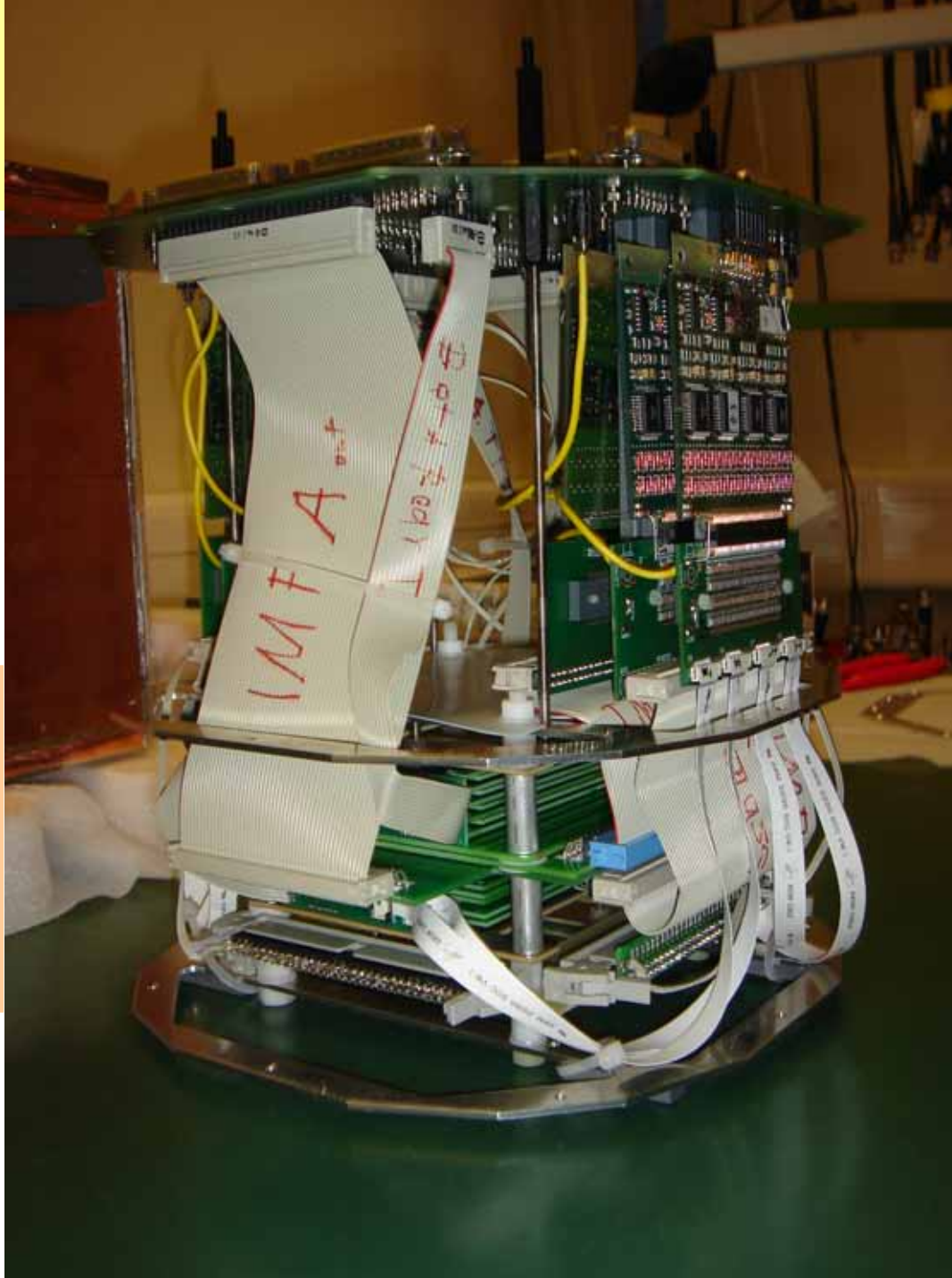


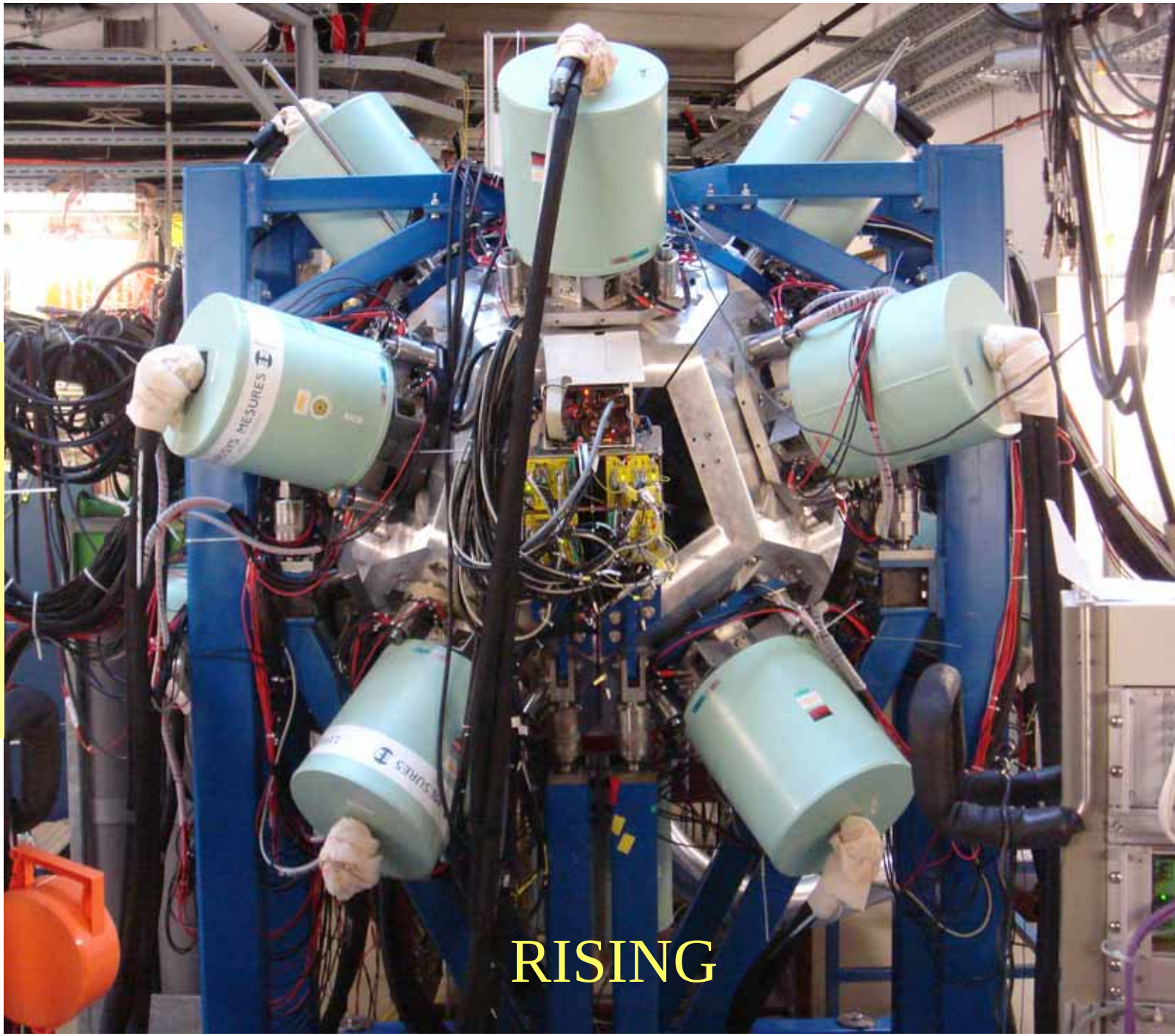
pixels in implantation zone:
3x60x40 = 7200

and how it looks in reality



^{100}Sn





+

15 x 7

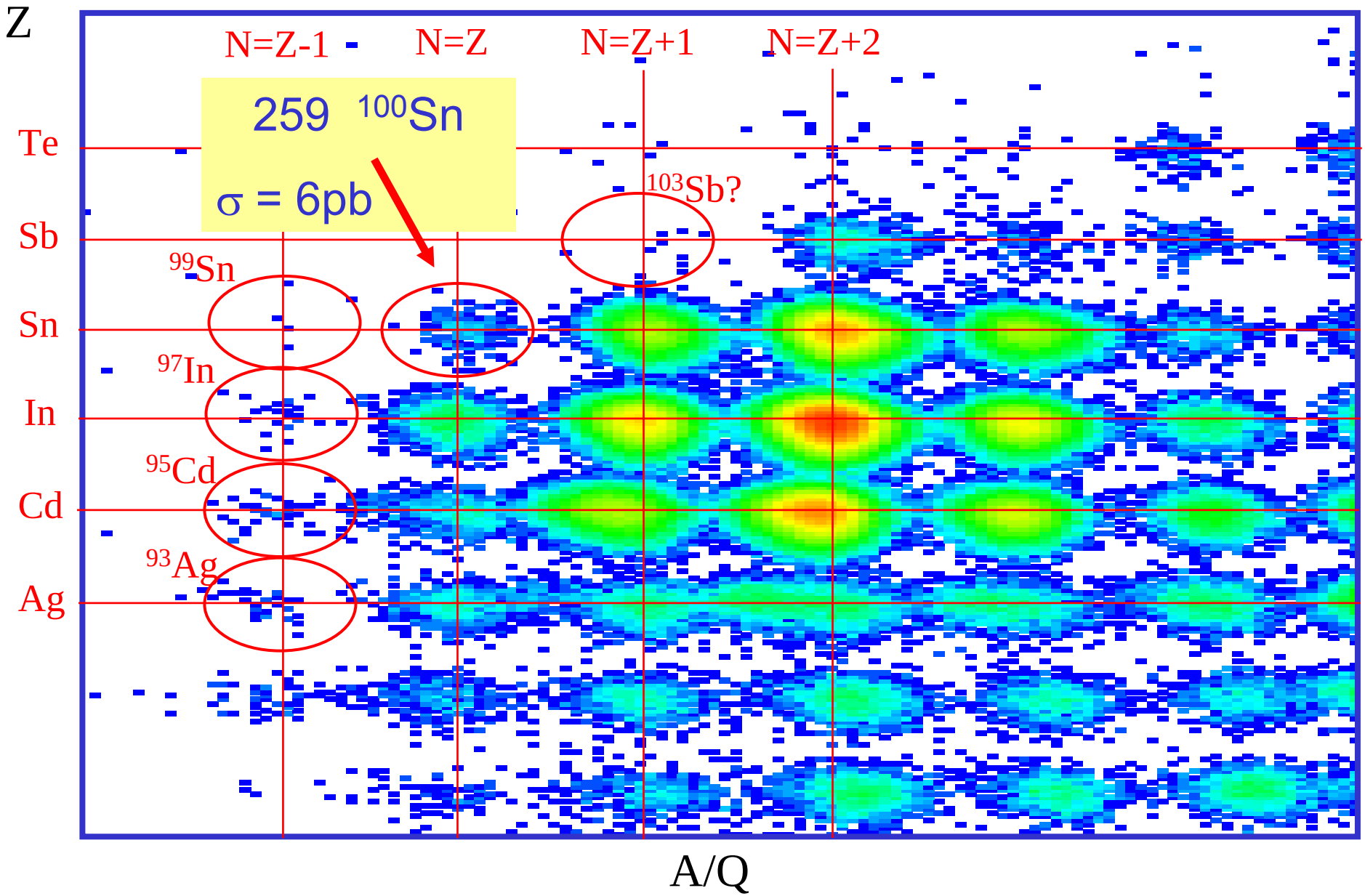
Germanium detectors

ε_{Photo}~ 11%

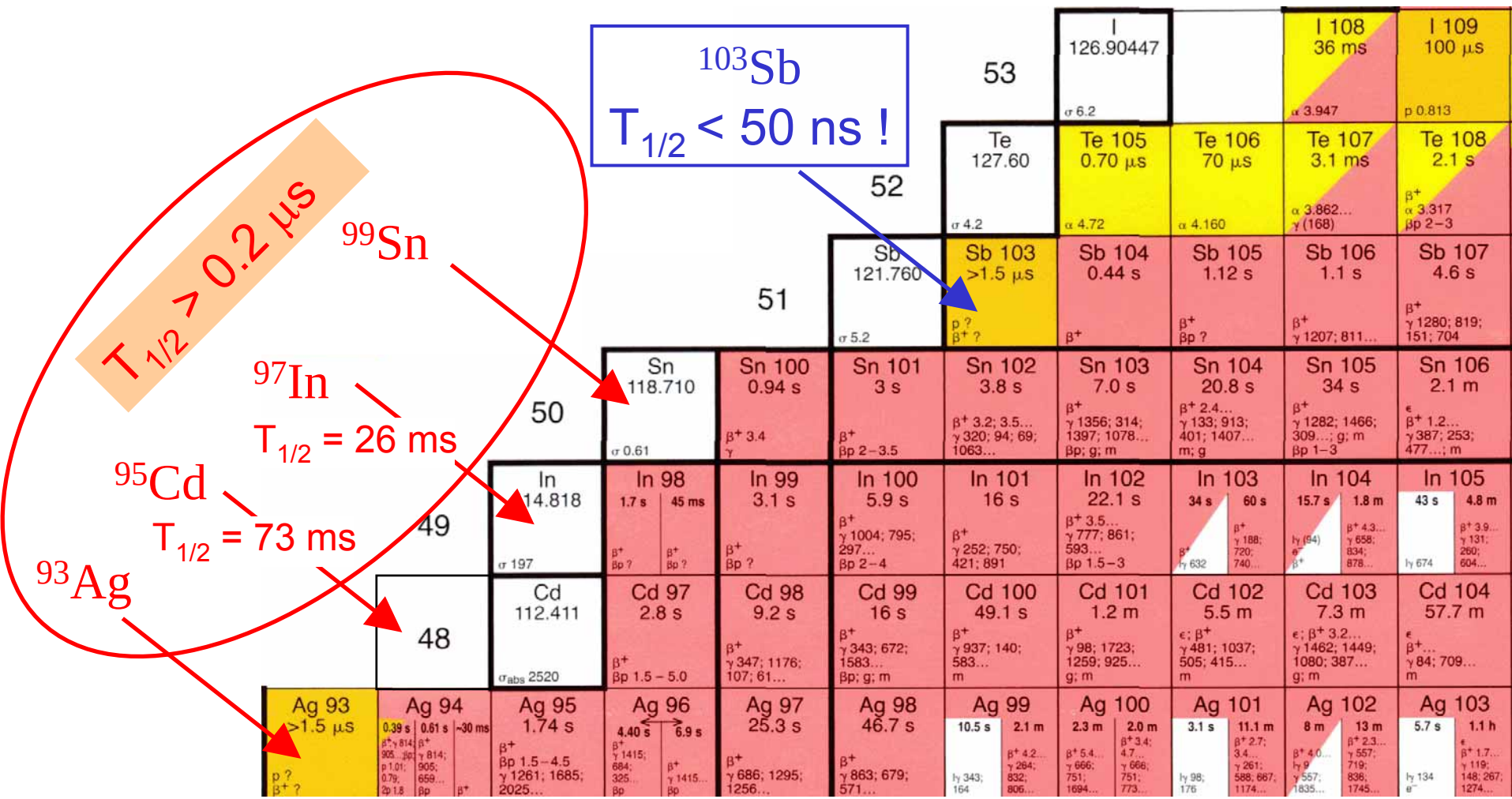
@ 662 keV

New Nuclides?

^{100}Sn setting (full statistics, 15 days)

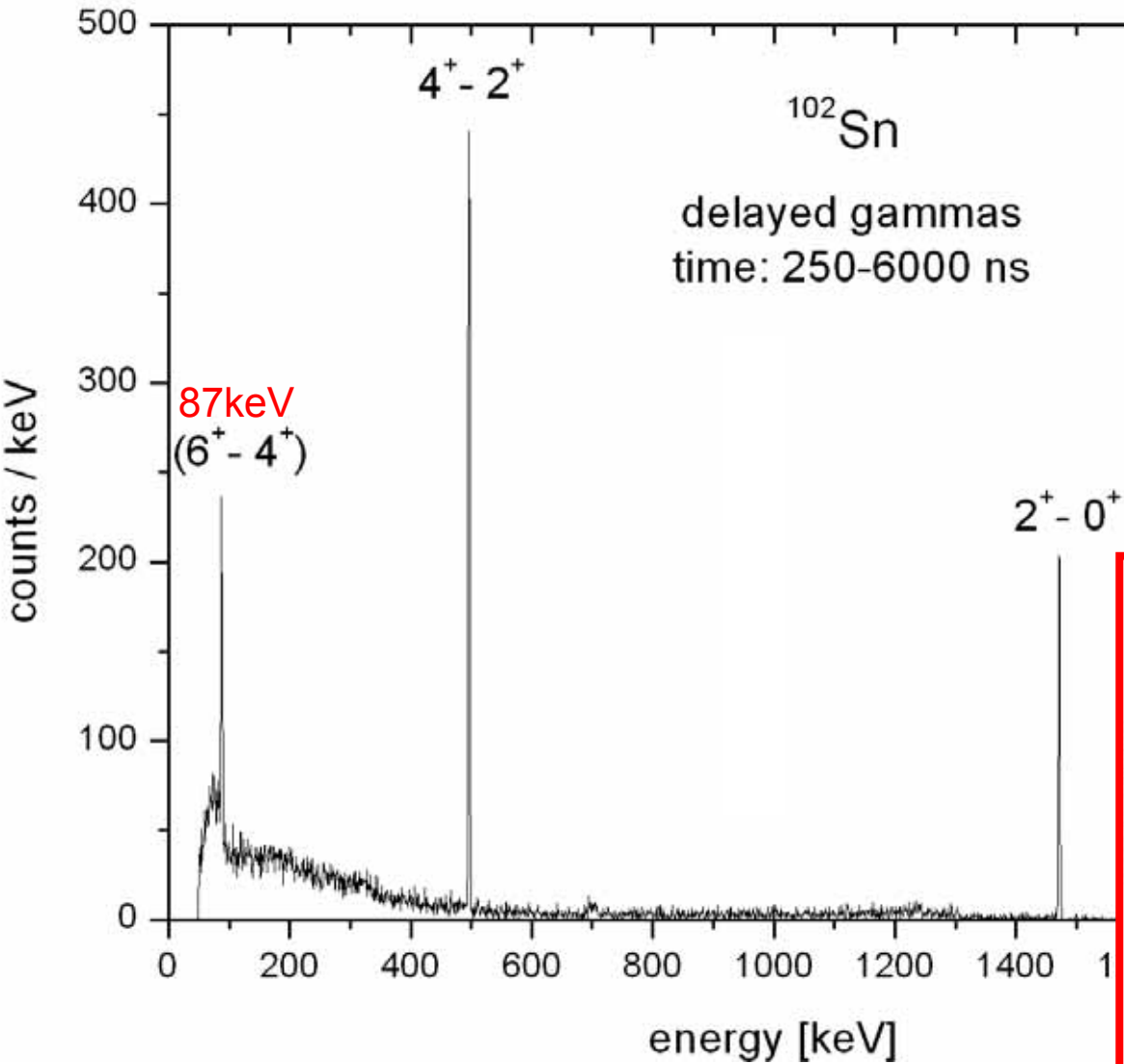


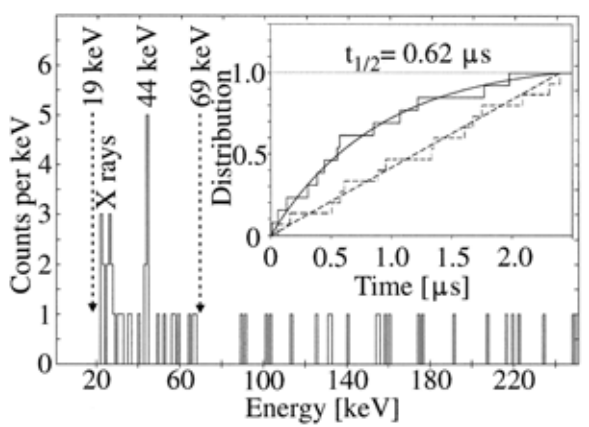
what's new?


^{103}Sb
$T_{1/2}$ < 50 ns !
$T_{1/2}$ > 0.2 µs
^{99}Sn
^{97}In
$T_{1/2}$ = 26 ms
^{95}Cd
$T_{1/2}$ = 73 ms
^{93}Ag
53
52
51
50
49
48
I 126.90447
I 108 36 ms
I 109 100 µs
Te 127.60
Te 105 0.70 µs
Te 106 70 µs
Te 107 3.1 ms
Te 108 2.1 s
Sb 121.760
Sb 103 >1.5 µs
Sb 104 0.44 s
Sb 105 1.12 s
Sb 106 1.1 s
Sb 107 4.6 s
Sn 118.710
Sn 100 0.94 s
Sn 101 3 s
Sn 102 3.8 s
Sn 103 7.0 s
Sn 104 20.8 s
Sn 105 34 s
Sn 106 2.1 m
In 114.818
In 98 1.7 s 45 ms
In 99 3.1 s
In 100 5.9 s
In 101 16 s
In 102 22.1 s
In 103 34 s 60 s
In 104 15.7 s 1.8 m
In 105 43 s 4.8 m
Cd 112.411
Cd 97 2.8 s
Cd 98 9.2 s
Cd 99 16 s
Cd 100 49.1 s
Cd 101 1.2 m
Cd 102 5.5 m
Cd 103 7.3 m
Cd 104 57.7 m
Ag 93 >1.5 µs
Ag 94 0.39 s 0.61 s ~30 ms
Ag 95 1.74 s
Ag 96
Ag 97 25.3 s
Ag 98 46.7 s
Ag 99 10.5 s 2.1 m
Ag 100 2.3 m 2.0 m
Ag 101 3.1 s 11.1 m
Ag 102 8 m 13 m
Ag 103 5.7 s 1.1 h

Isomers?

6^+ Isomer in ^{102}Sn

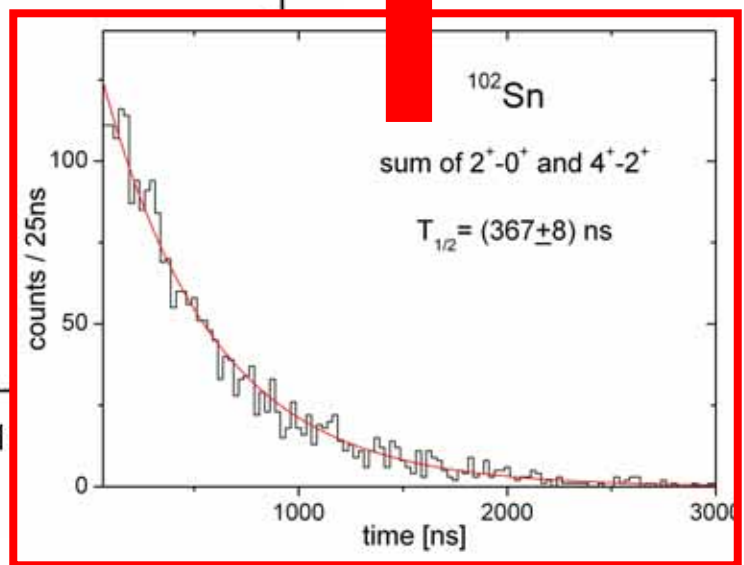




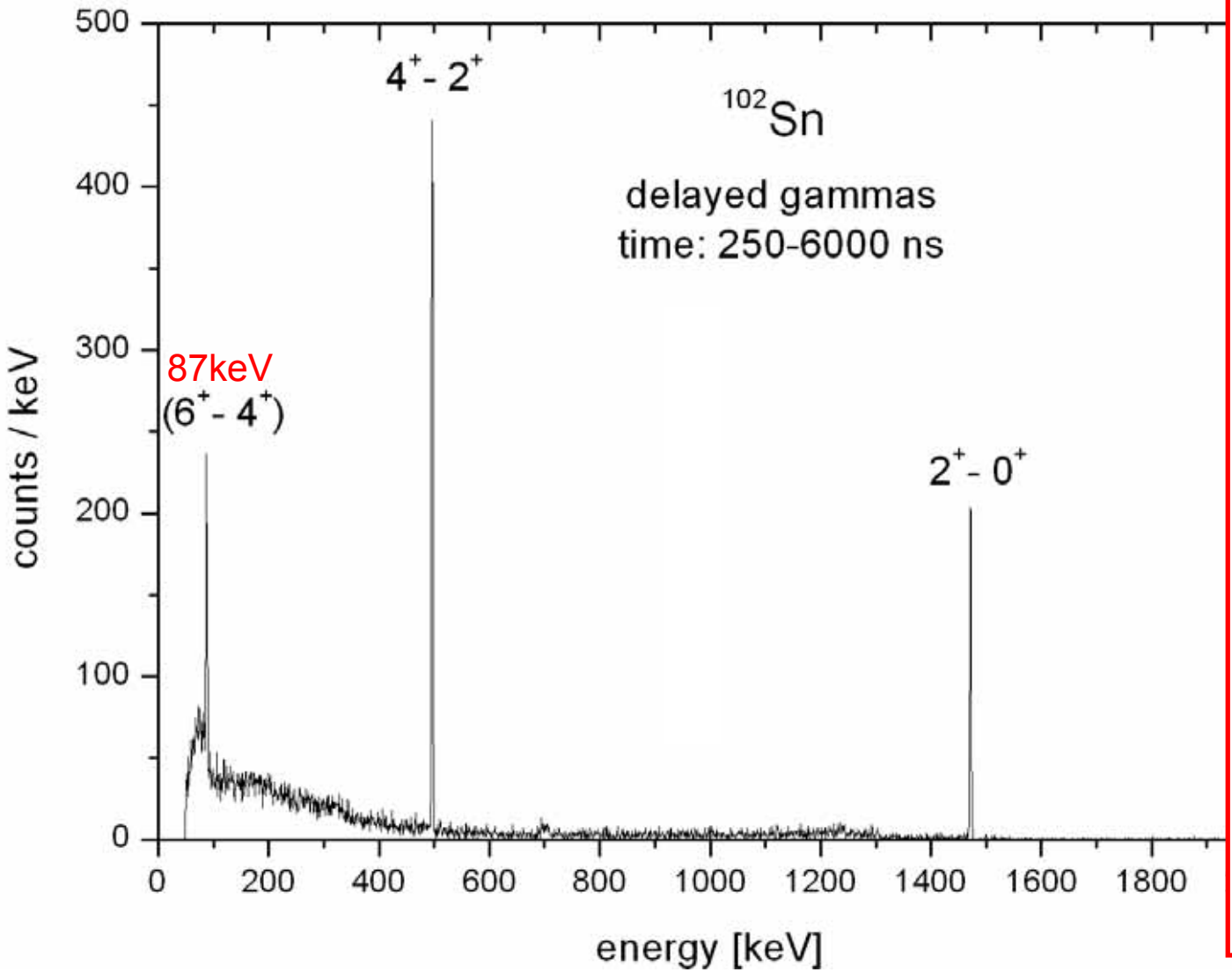
Lipoglavsek et al., PLB 1998

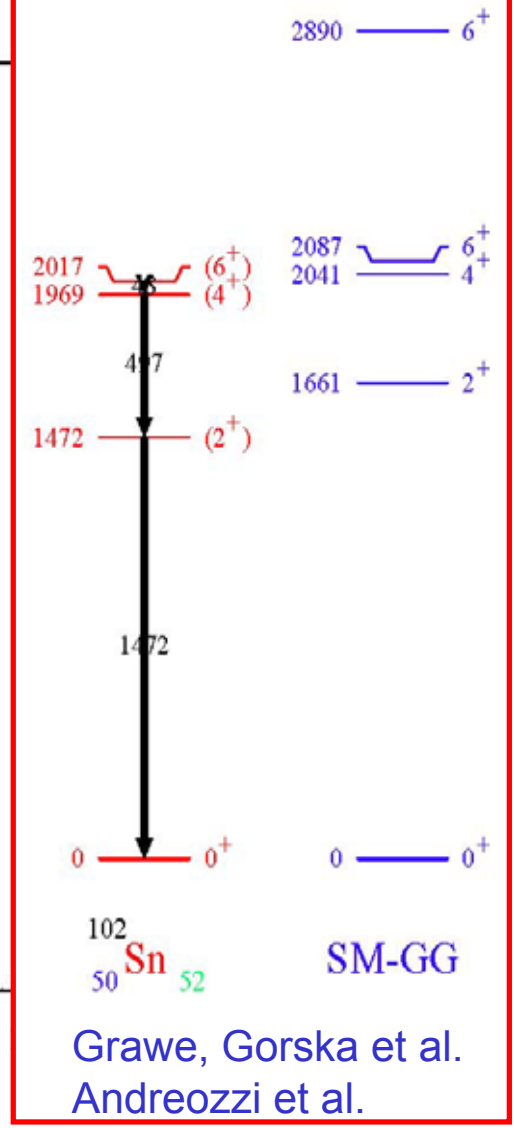
E(6-4) = 48keV

B(E2)=3.2(1) W.u.



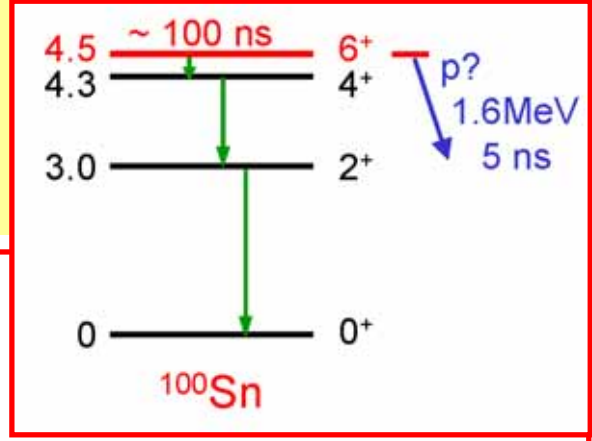
6^+ Isomer in ^{102}Sn

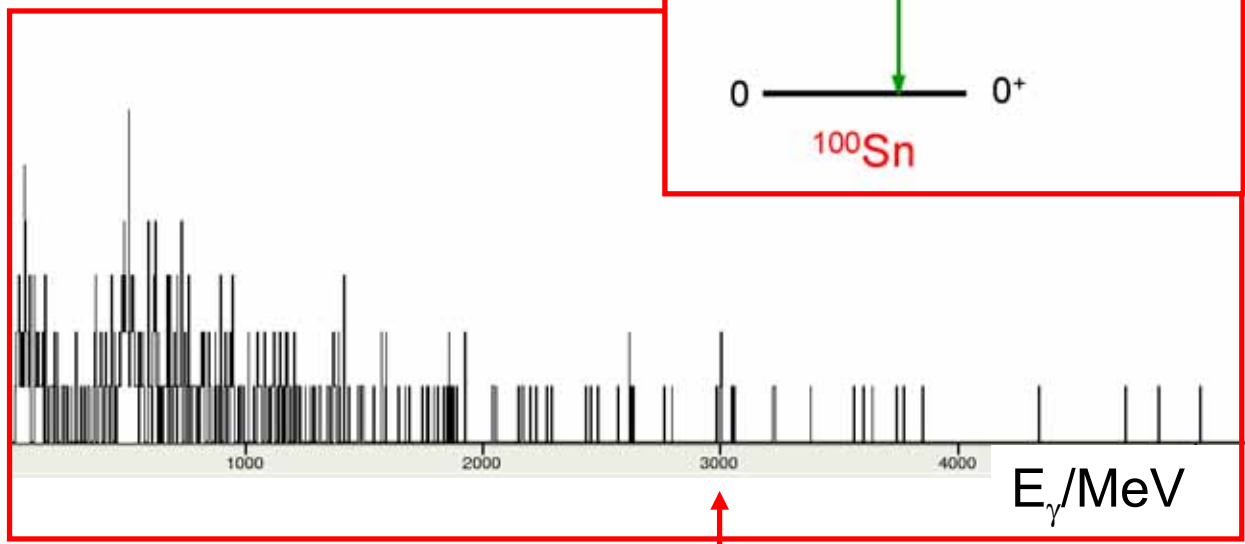




Grawe, Gorska et al.
Andreozzi et al.

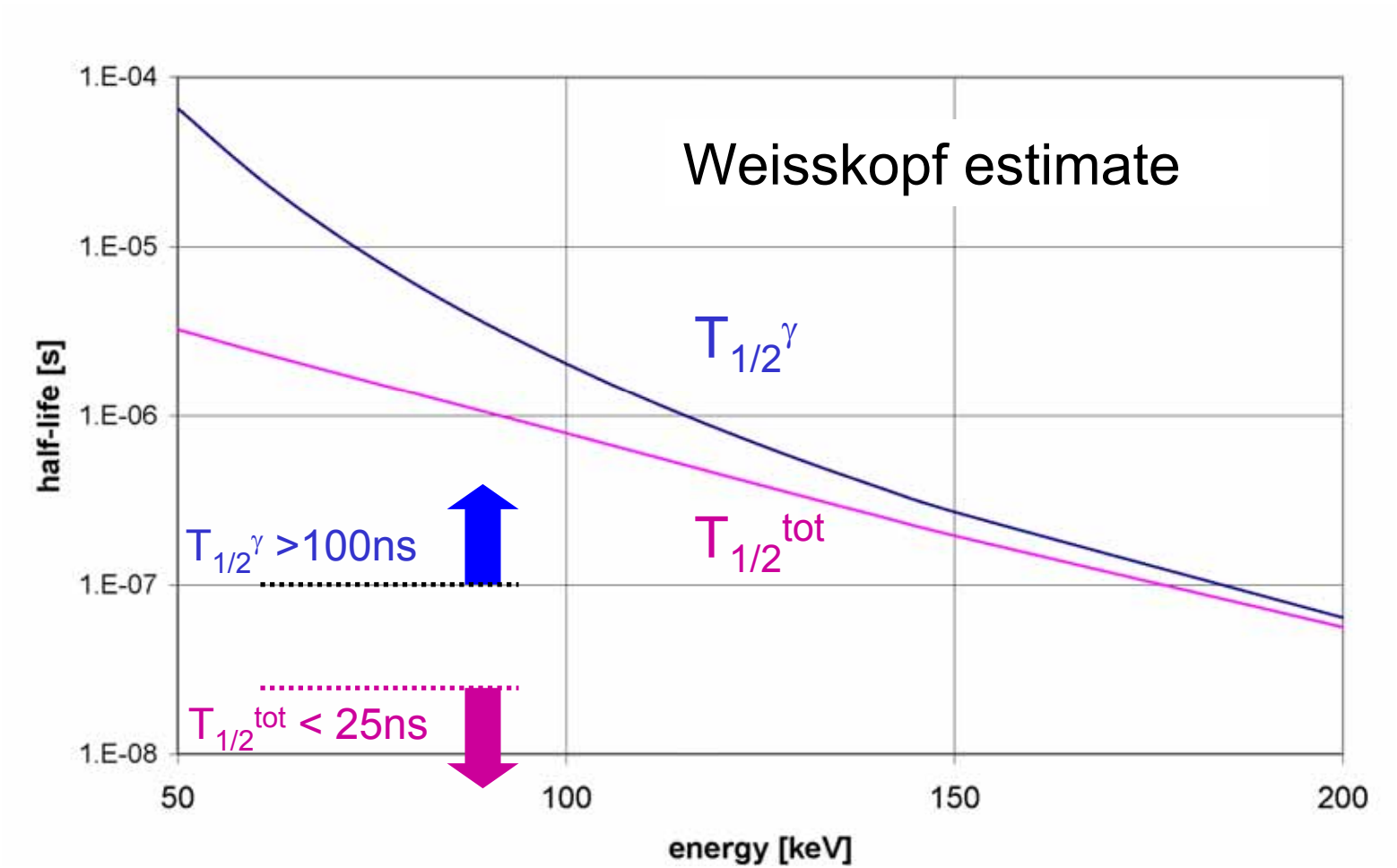
Search for 6^+ isomer in ^{100}Sn





3 isomer decays after ToF=200ns
decaying within 25 ns ?

6^+ Isomer in ^{100}Sn ?



probably not

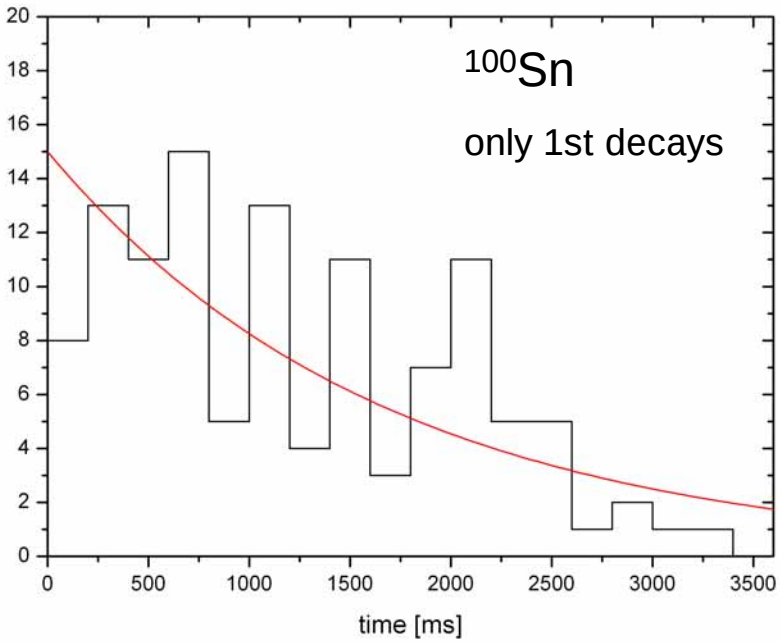
how does ^{100}Sn decay?

Correlation of Implantation and Decay

require same position within ± 1mm in x,y,z

record all decay triggers within 15 s
(β^+ of 3 generations)

Maximum Likelihood analysis
varying the ^{100}Sn half-life
with known: daughter decays,
efficiencies, dead times, background



$T_{1/2}$ = 1.16 ± 0.20 s

preliminary

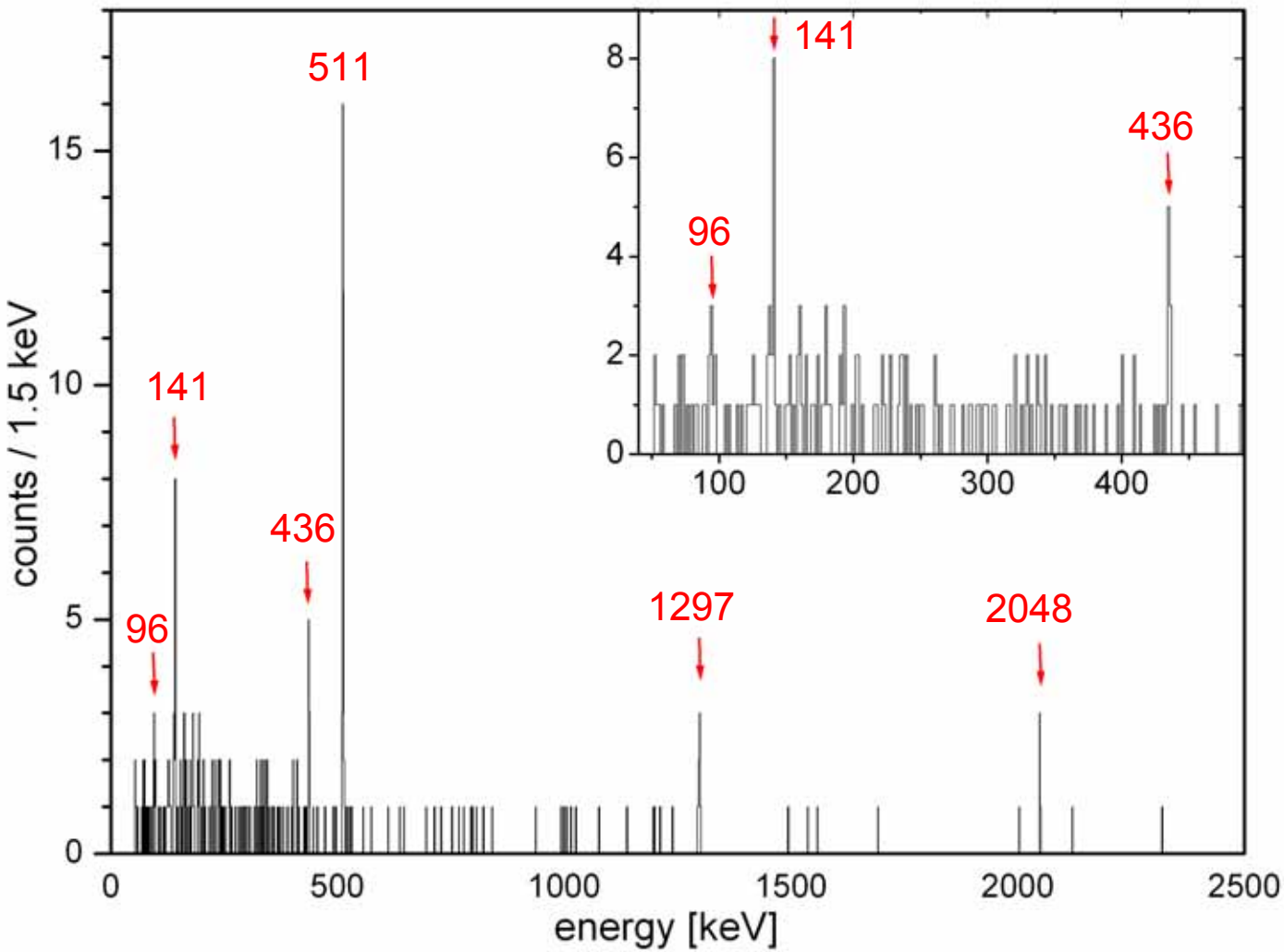
Comparison:

MSU 2007 $0.55^{+0.70}_{-0.31}$ s

GSI 1997 $0.94^{+0.54}_{-0.26}$ s

Gamma Spectrum after Beta Decay of ^{100}Sn

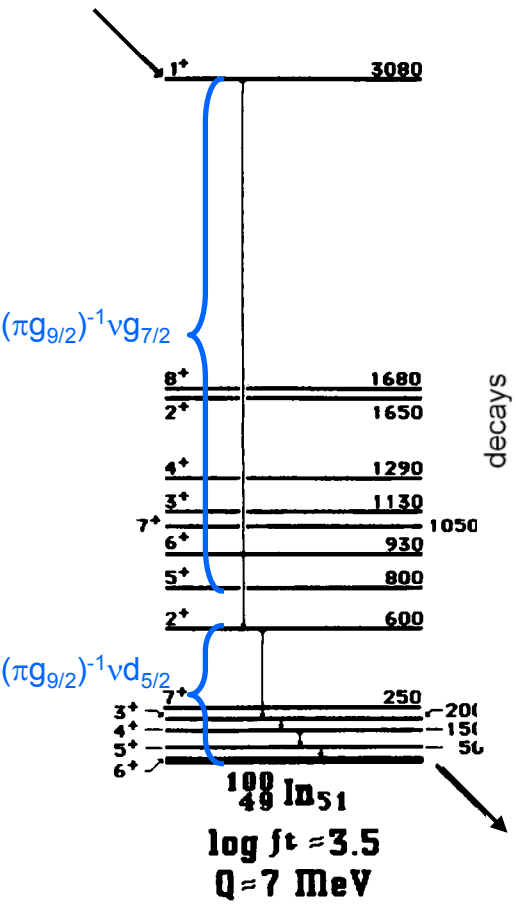
all events within 4 s after implantation



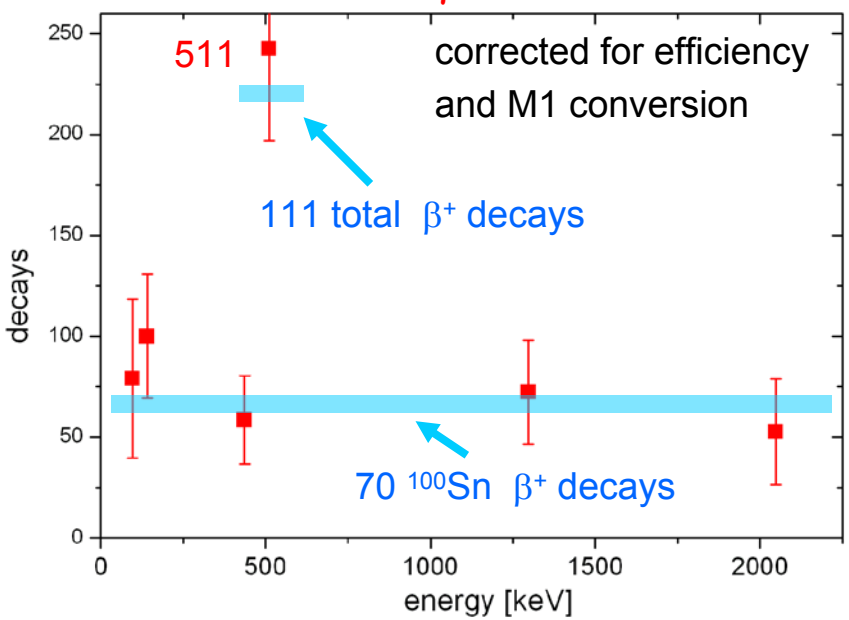
Gamma Intensities

what do we expect?

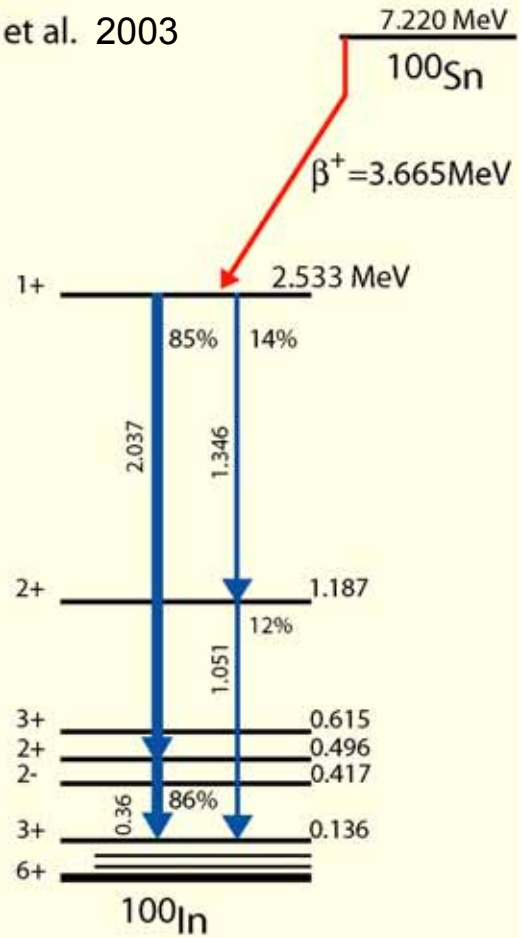
Stone, Walters 1985



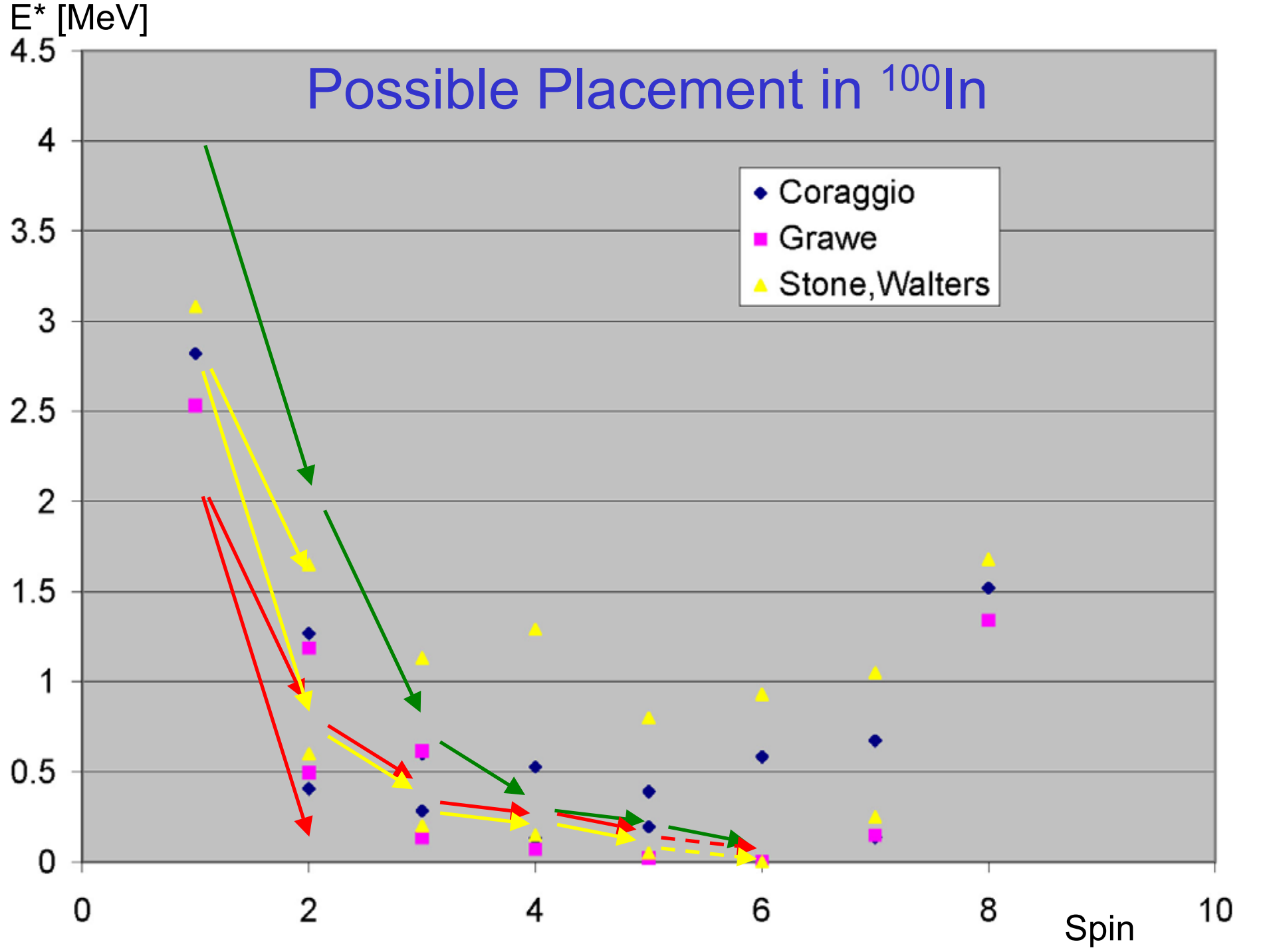
γ intensities



Grawe et al. 2003



5 lines add up to
4018 keV ???


Possible Placement in 100In
E* [MeV]
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
Spin
Coraggio
Grawe
Stone,Walters

most probably choice N^{o} 3

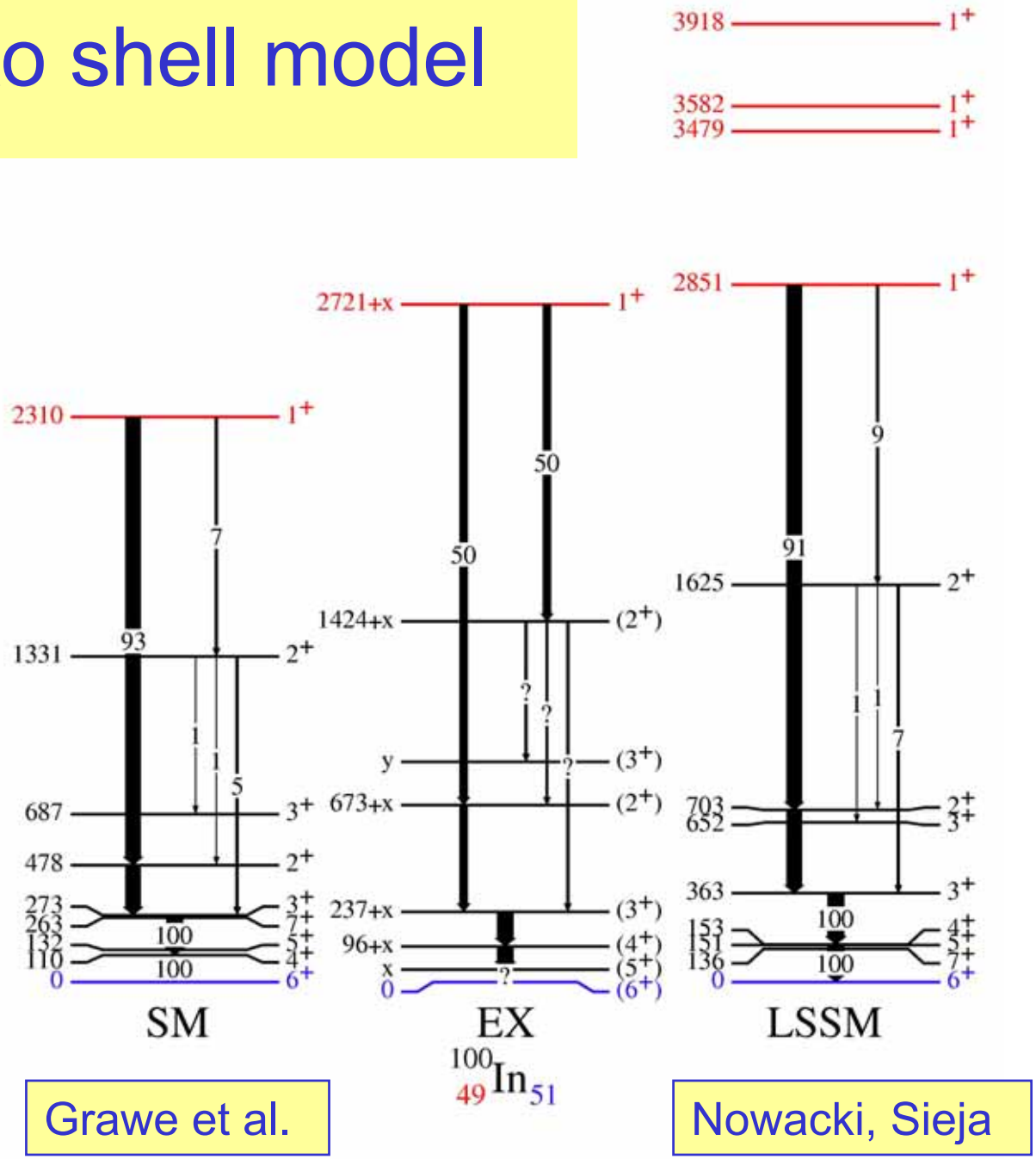
$E^*(1+) = (2.71 + x)$ MeV with $x \approx 0.05$ MeV

because:

- total sum energy = 2.76(0.43) MeV (Schneider et al.)
- $\Delta Mc^2 - Q_{EC}(1^+)$= 2.6(1.0) MeV (Chartier et al.)
- one β-delayed proton event:

  $E_p + S_p(^{100}In)$ = 2.93(0.34) MeV (Audi et al.)

compare to shell model



Grawe et al.

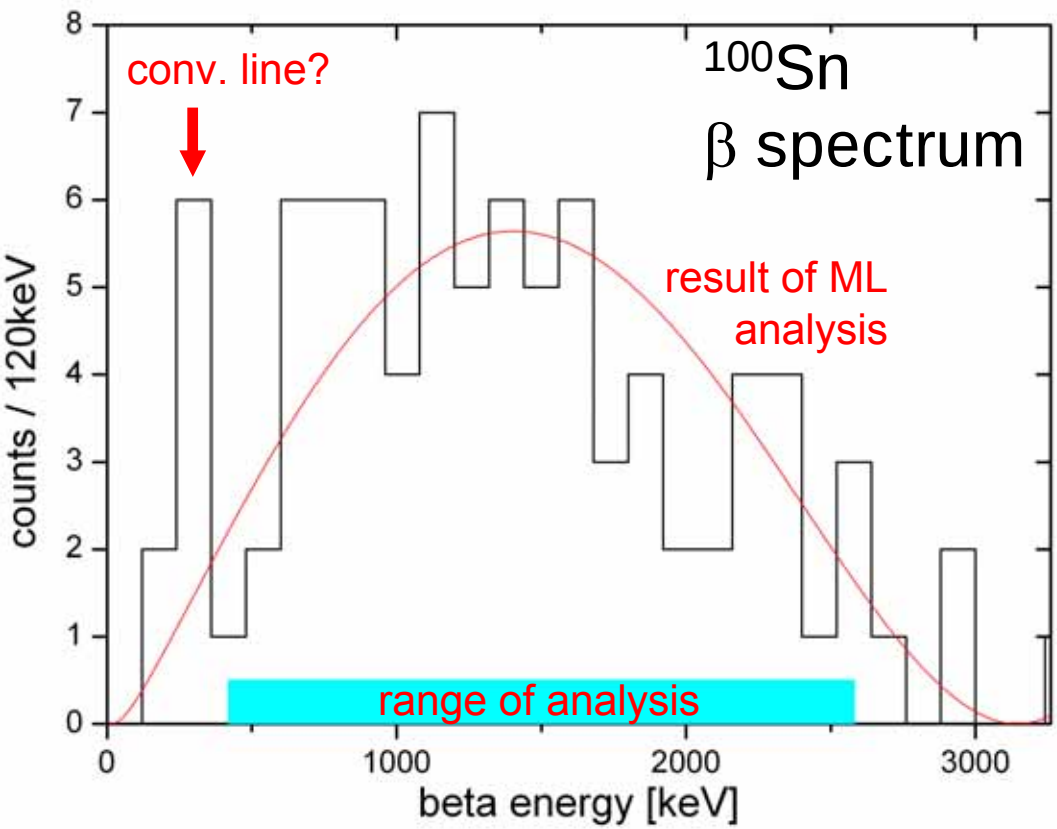
Nowacki, Sieja

Extraction of Beta Spectrum

sum over total energy within 3 s after implantation

in implantation zone + calorimeter

tested (by eye) for uninterrupted tracks



from maximum likelihood

E_{max} = 3.29 ± 0.20 MeV

Q_{EC} = 4.31 ± 0.20 MeV

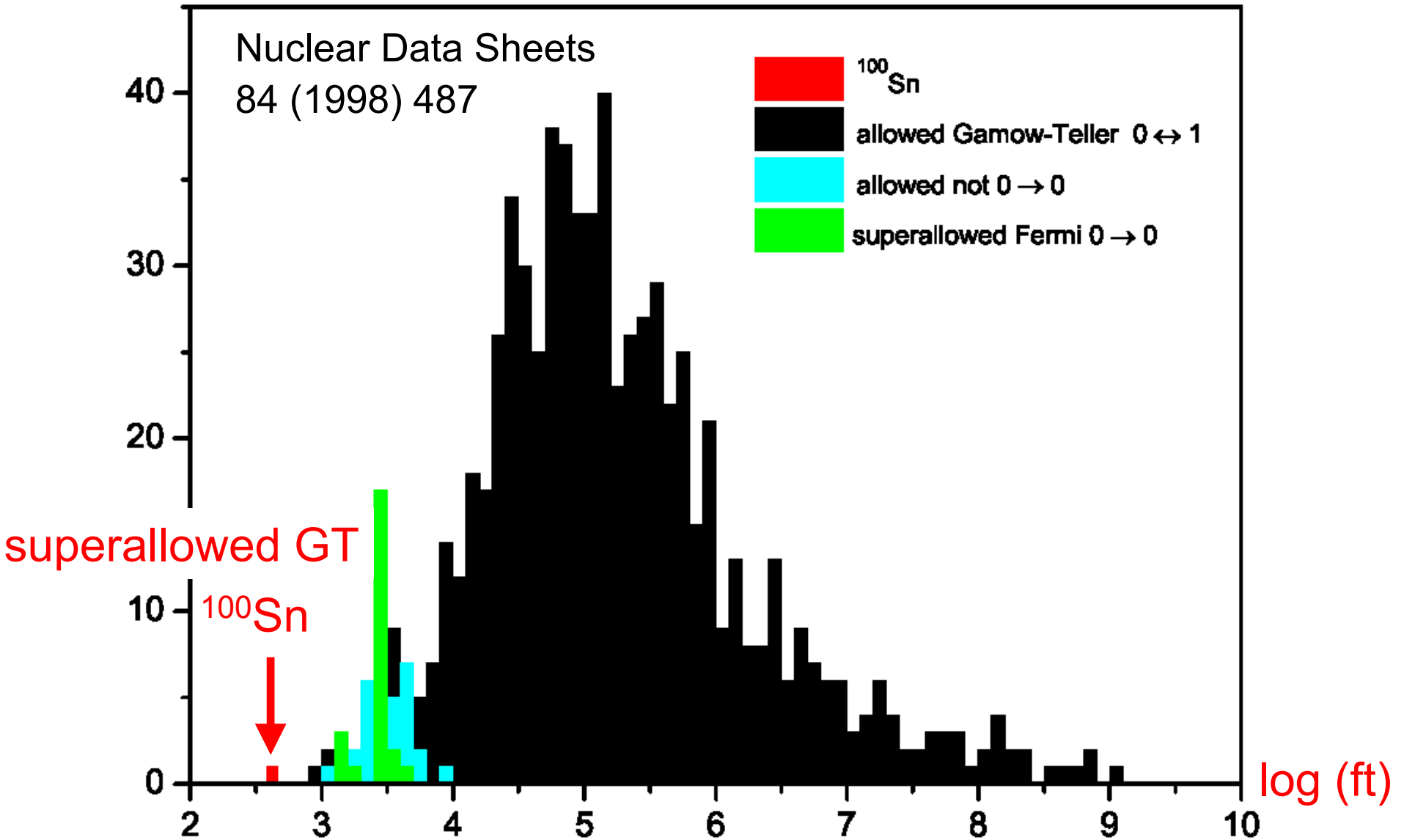
to excited state

=> $I(\beta^+) = 87\%$

=> log ft = 2.62 $^{+0.13}_{-0.19}$

world champion

known log(ft) values



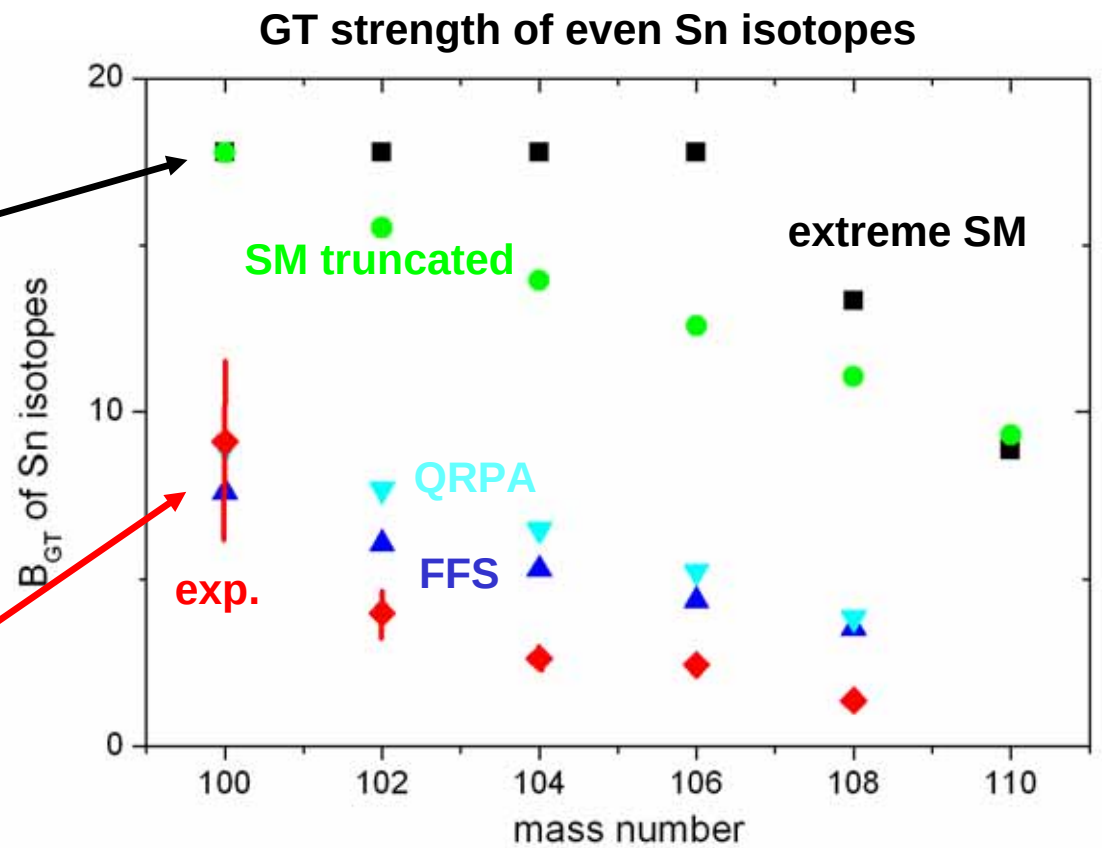
Gamow Teller Strength

$$B_{GT}^{ref} = \frac{4l}{2l+1} \cdot N_{\pi g9/2} \cdot \left(1 - \frac{N_{\nu g7/2}}{8}\right)$$

$$B_{GT}^{ref} = 17.8$$

$$B_{GT}^{\exp} = \frac{2Ft}{(g_A/g_V)^2\, ft} = \frac{6142.8s}{1.2695^2 \cdot ft}$$

$$B_{GT}^{\exp} = 9.1^{+2.6}_{-3.0}$$



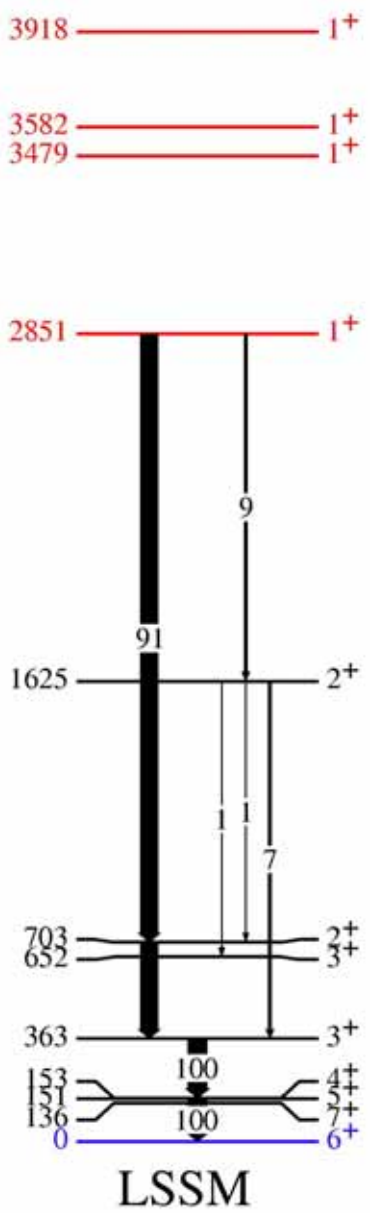
additional 1+ states?

assume additional 1+ states, e.g. with energies and relative strength of LSSM (Novacki, Sieja)

E_x	E_max	Q	B_GT	norm. Int.	E_max_mean	ft	B_GT
LSSM			LSSM				
2.963	**3.363**	4.385	5.684	0.9108	3.063	503.3	**7.57**
3.696	2.630	3.652	1.022	0.0616	0.162	2799.4	1.36
3.760	2.566	3.588	0.228	0.0125	0.032	12548.0	0.30
4.118	2.208	3.230	0.470	0.0151	0.033	6087.1	0.63
			7.404	1.0000	**3.2900**		**9.86**

$$B_{GT}^{LSSM}(1_1^+) = 5.7$$

$$B_{GT}^{\exp}(1_1^+) = 7.6\,^{+2.2}_{-2.5}$$



why is B_{GT} that large?

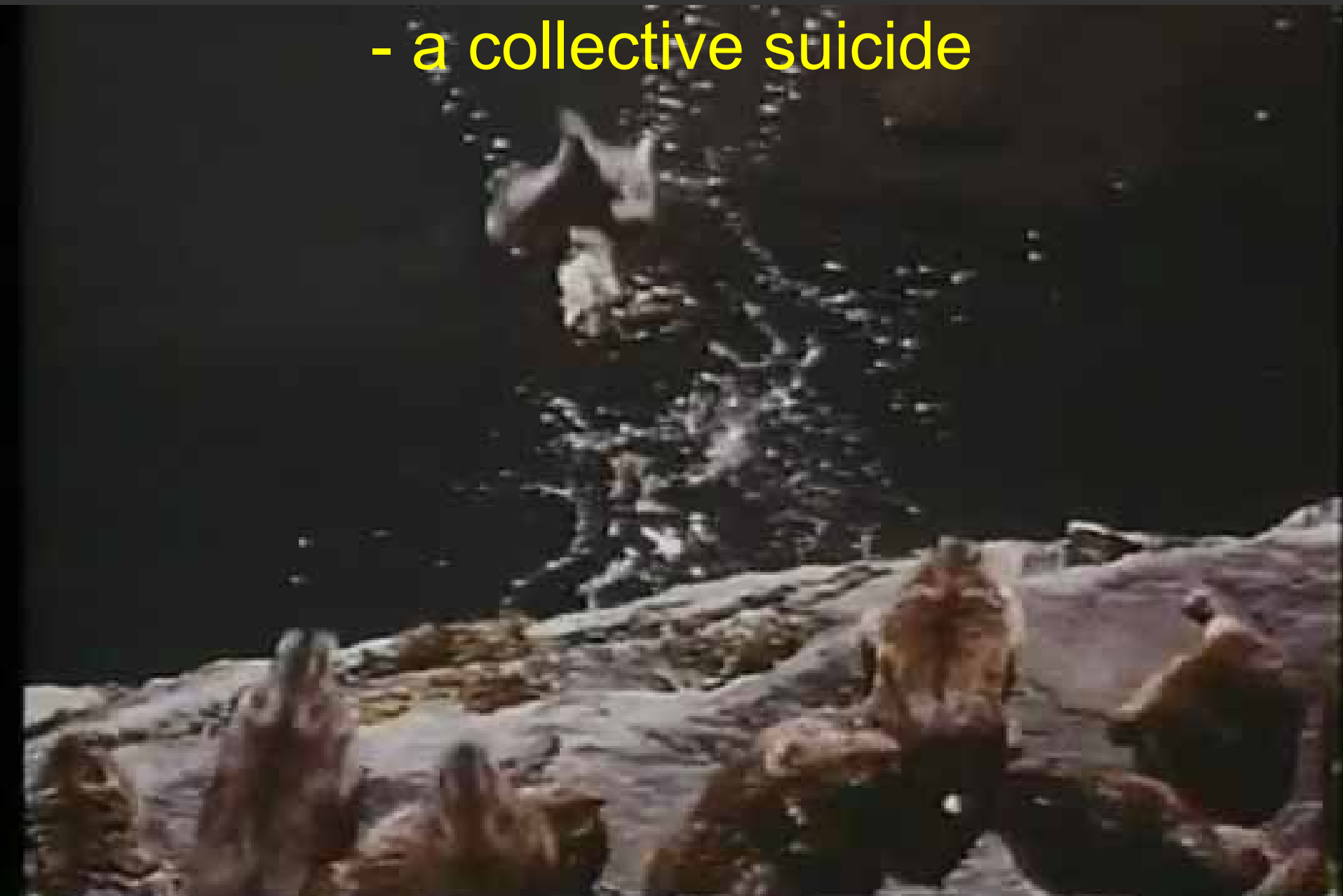
wave functions must be rather pure

$$| i > = \{(\pi g_{9/2})^{10}\}\ 0^+$$

$$< f | = \{(\pi g_{9/2})^{9}\ (\nu g_{7/2})^{1}\}\ 1^+$$

10 protons can transform into a neutron

10 protons want to decay
- a collective suicide



Conclusions

- first observation of ^{93}Ag, ^{95}Cd, ^{97}In, and ^{99}Sn
- reduced rate of ^{103}Sb => $T_{1/2} < 50$ ns
- ^{102}Sn: new isomeric state
- ^{100}Sn: probably no isomer
- 1st γ-spectrum after decay of ^{100}Sn
- ^{100}Sn decay: $T_{1/2}$, E_β^{max}, E_γ, B_{GT}
- superallowed GT transition

=> dominant configurations $(\pi g_{9/2})^{10}$ =>$(\pi g_{9/2})^{9}$ $(\nu g_{7/2})^{1}$

Conclusions

the ^{100}Sn shell gap

is robust

- doubly magic -

The ^{100}Sn Team

photo taken by Hans Geissel

The ^{100}Sn Team

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P.-A.Söderström (13), S.Steer (5), A.Stolz (15), P.Strmeň (11),
and the RISING collaboration

(1) TU München, (2) GSI, (3) U of Edinburgh, (4) IFJ PAN Krakow, (5) U of Surrey,
(6) U of Ankara, (7) U of Köln (8) Inst. Vinca Belgrade, (9) RIKEN, (10) GANIL,
(11) U of Bratislava, (12) U of Warsaw, (13) U of Uppsala, (14) KVI - U of Groningen, (15) MSU

Lehrstuhl E12

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RISING

The ^{100}Sn Team

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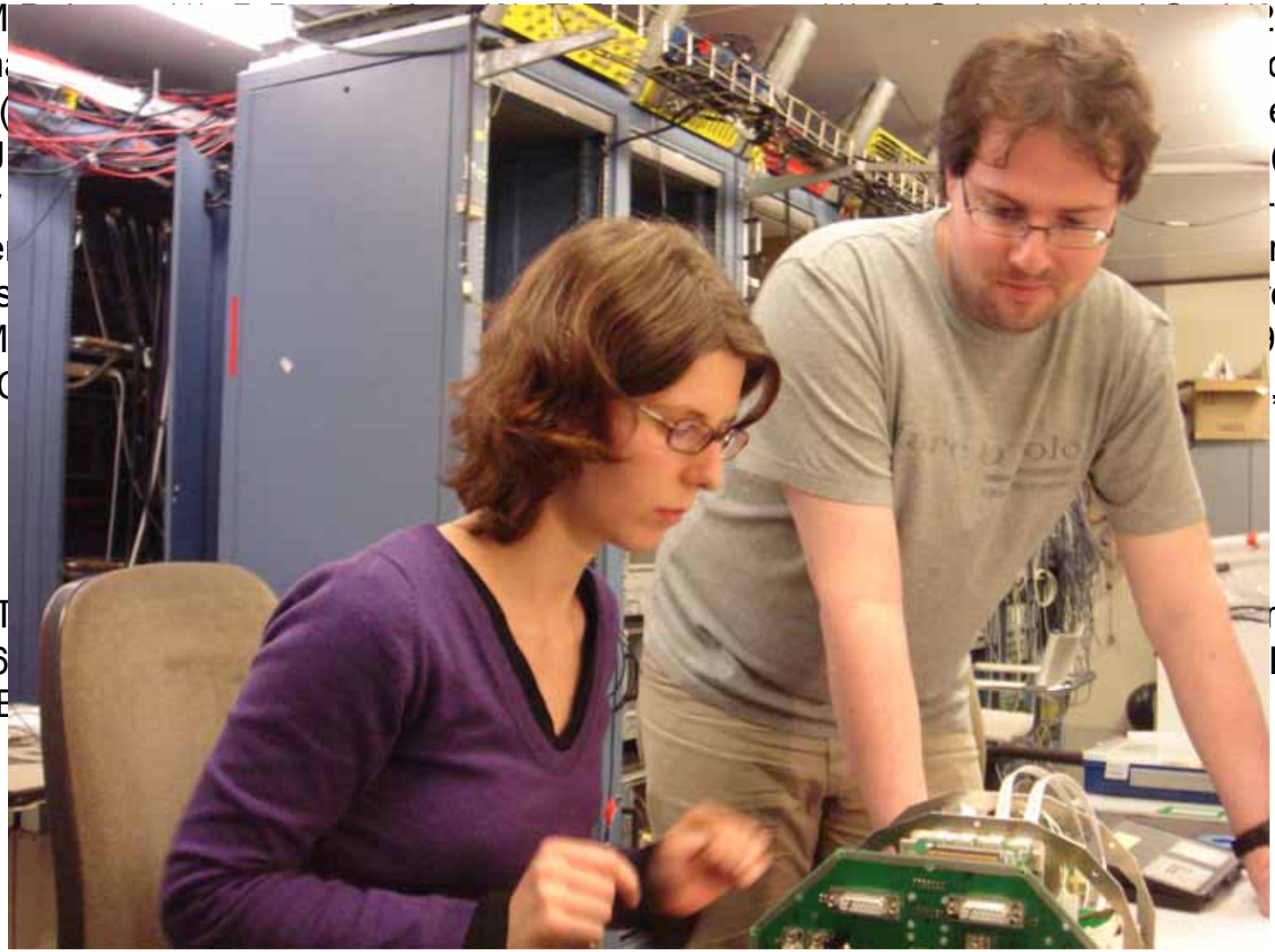

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