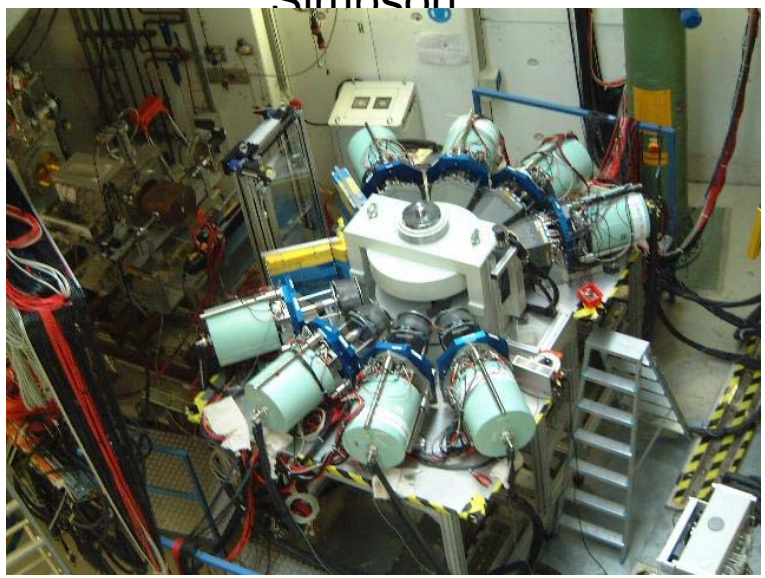
g-RISING

g-factor measurements on spin-aligned isomeric beams using the RISING cluster detectors.

Gary Simpson LPSC, Grenoble

Spokesperson for the g-RISING collaboration: Gerda Neyens

Co-spokespersons: Dimiter Balabanski, Jurgen Gerl, Micha Hass, Adam Maj, Gary Simpson



GENERAL MOTIVATION for g-factor measurements at FRS+RISING

g-factors 0 reveal information about the nuclear single-particle structure:
wave function, spin, magnetic dipole operator, □

0 unique probe to study changes in nuclear shell structure far from stability

spin-alignment - in relativistic fission
- for projectile fragmentation beams with Z>30
0 never experimentally proven !

0 medium-heavy neutron rich nuclei become accessible for moments studies

WHY AT THE FRS ?

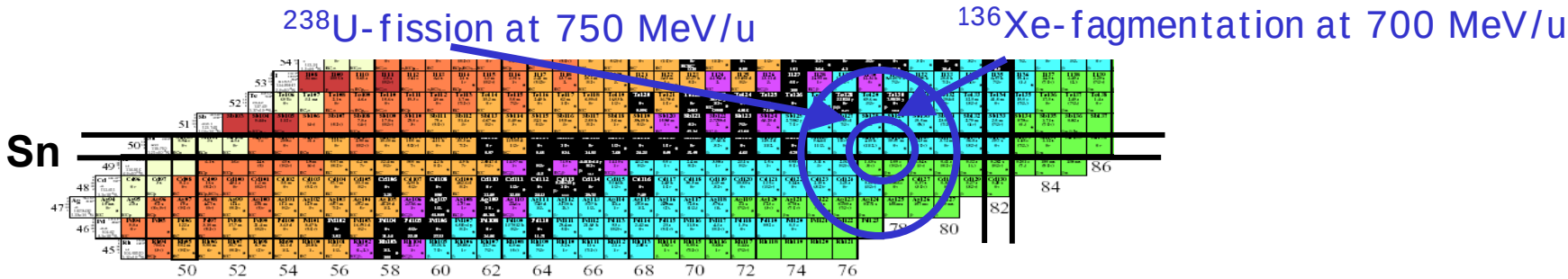
= one of the few places to study g-factors and quadrupole moments of **spin-aligned isomeric beams.**

- lifetime range 100 ns □ 50 µs (not at ISOL facilities)
- in neutron rich nuclei with mass A>70
  (not with intermediate energy fragmentation -not fully stripped)

Prepare for FAIR !

EXPERIMENTS performed Oct Dec. 2005

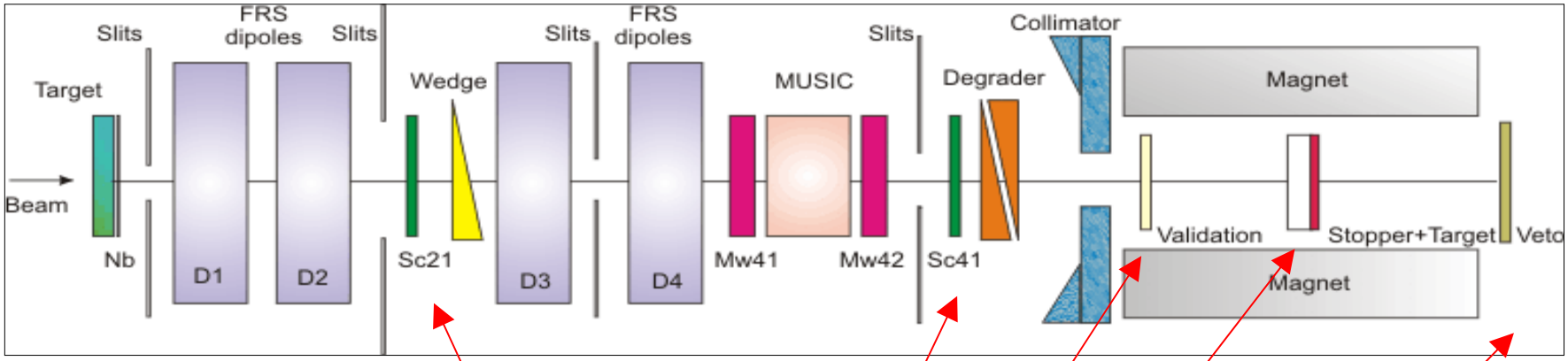
Spin-alignment in projectile fission and g-factors around ^{132}Sn
(Gerda Neyens and Gary Simpson)



Spin-alignment and g-factors of isomers in ^{127,128}Sn from fragmentation of a ^{136}Xe beam.
(Dimiter Balabanski and Michael Hass)

Spin-alignment and g-factor of isomers in the neutron deficient Pb-region.
(Adam Maj and Juergen Gerl)

EXPERIMENTAL SET-UP



Spin-aligned secondary beam selected
(S2 slits + position selection in **SC21**)

SC41 gives t=0 signal for γ-decay time measurement

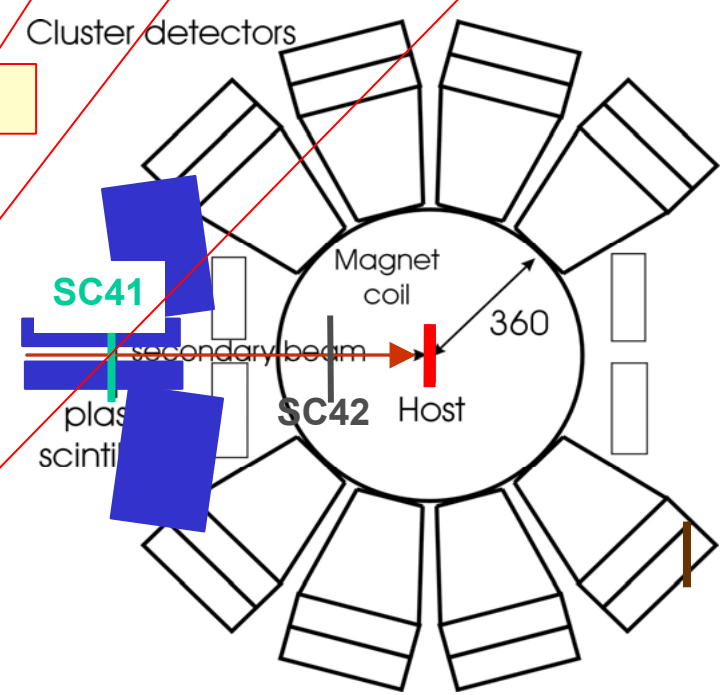
Pb-wall + collimator with ⌀ 7.5 cm
to avoid beam scattering

SC42 validates the event

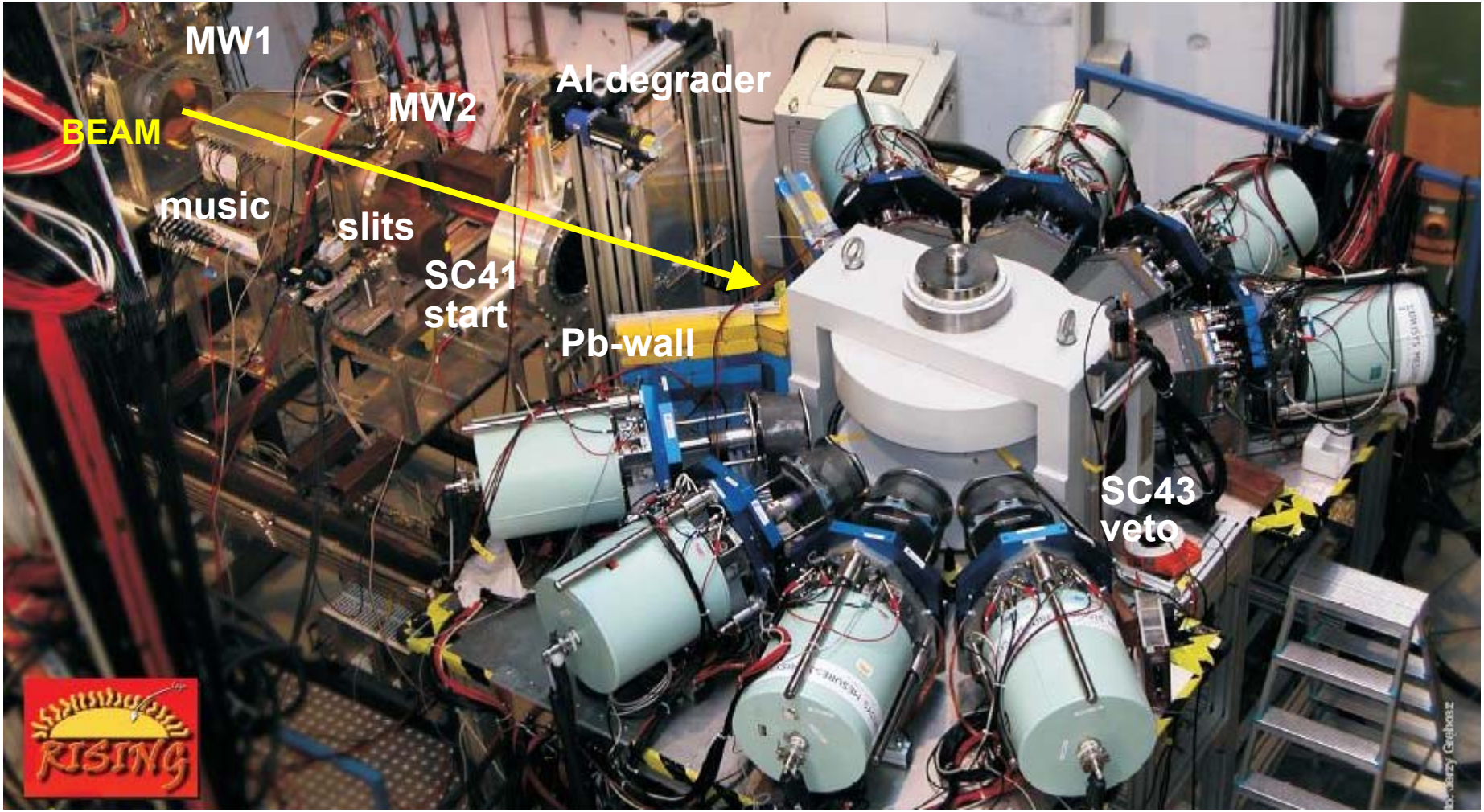
Implantation: plexi degrader + **2 mm Cu**
(annealed)

SC43 is a veto (reject particles not stopping in Cu)

magnet + 8 RISING detectors (top view)



g-RISING setup

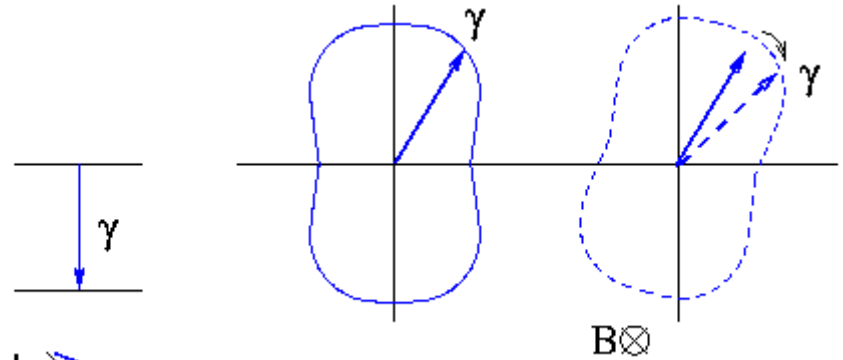


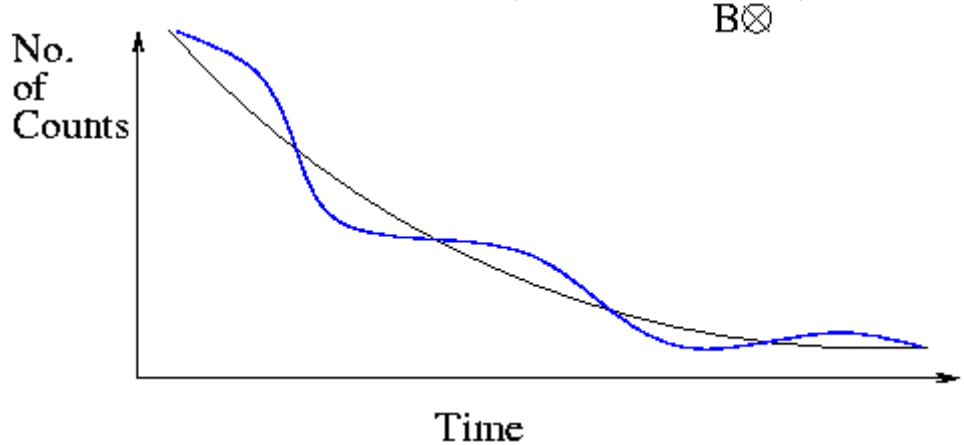
4 clusters with BGO anticompton shields and short collimators
4 clusters with the former RISING shields Electronics: VXI and DGF
Total efficiency = ~3 % at 1 MeV
Stopper: 20mm plexiglas + 2 mm Cu

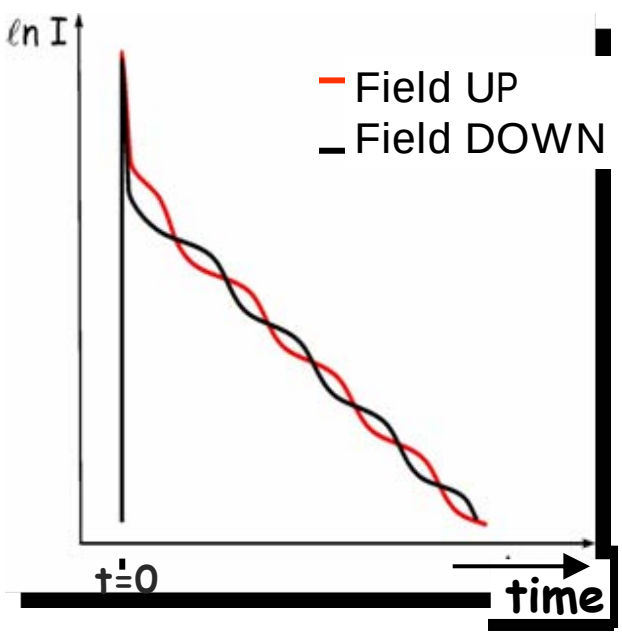
Experimental technique Time Differential Perturbed Angular Distribution

Spin-aligned nuclei Larmor precess in B field

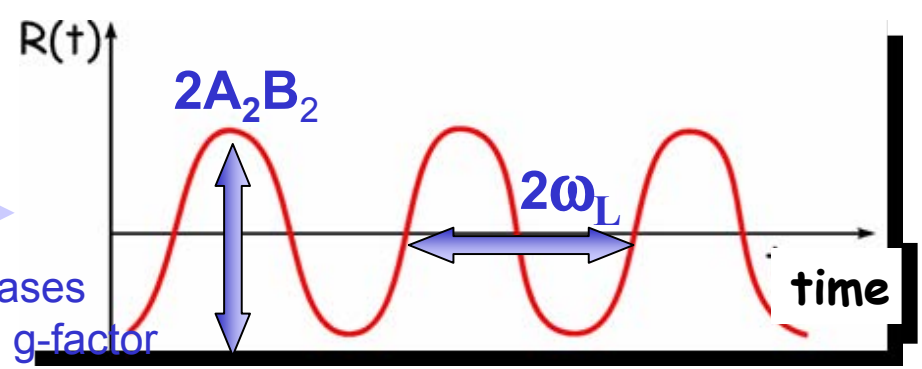
$$\omega_L = -g\mu_N B/\hbar$$







relative phases depend on g-factor

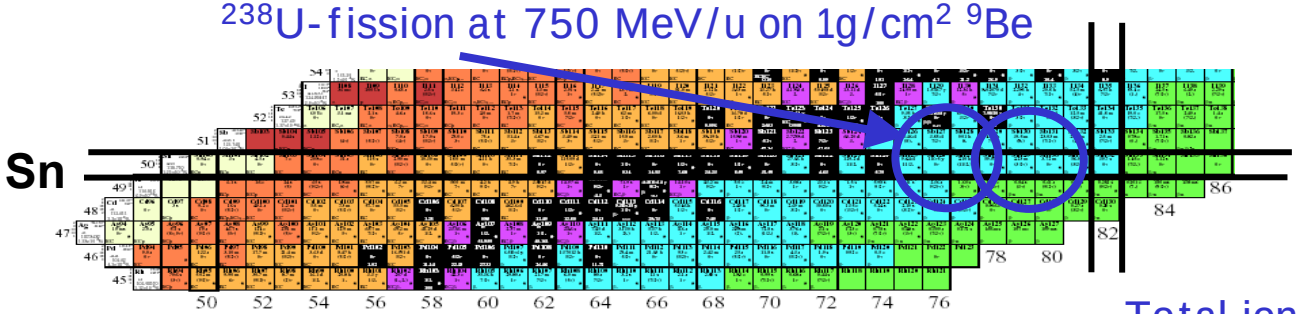


FIRST RESULTS

1. Spin-alignment in projectile fission and g-factors around ^{132}Sn

(Gerda Neyens and Gary Simpson)

^{238}U-fission at 750 MeV/u on 1g/cm^2 ^{9}Be

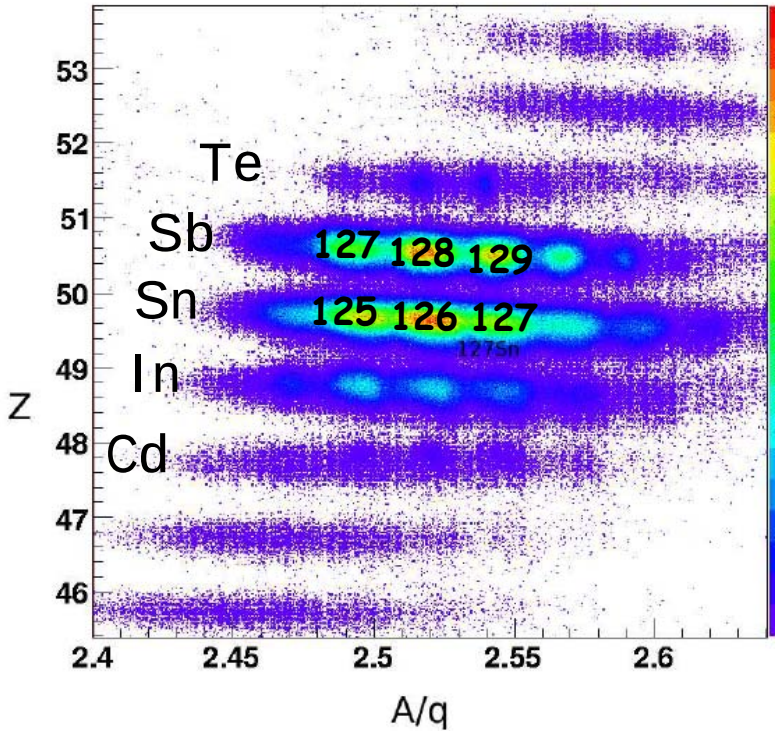


$I_{beam} = 5.10^8$/spill of 25 s

Total ion rate at S4 ≈ 30.000/spill

More than 30 isomers produced with enough statistics for

- 0 isomer search in Cd, In, Sn, Sb, Te, □
- 0 lifetimes
- 0 isomeric ratio□s

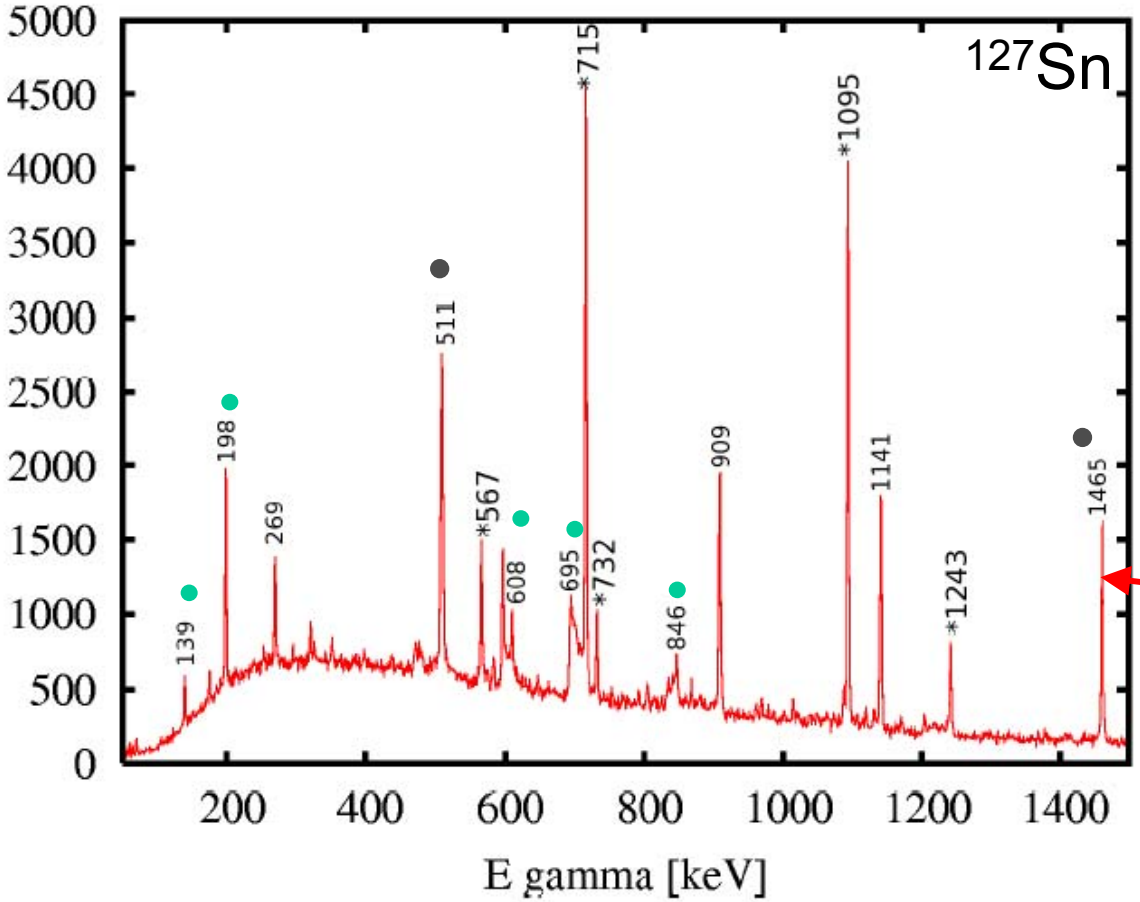


FIRST RESULTS

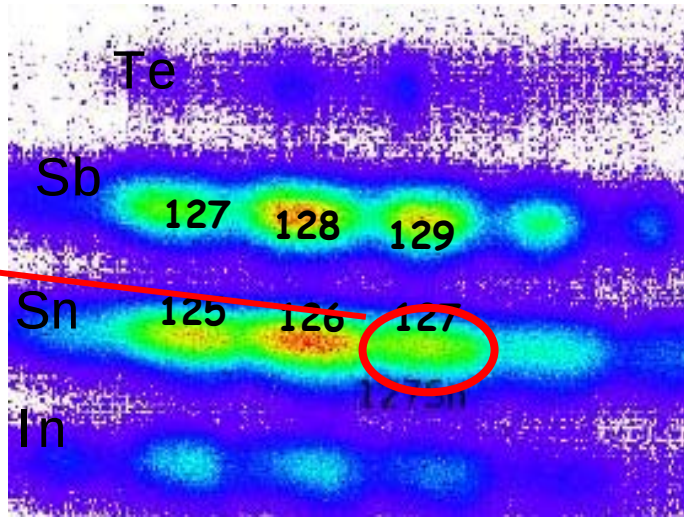
From G. Ilie

1. Spin-alignment in projectile fission and g-factors around ^{132}Sn 0 127Sn

Observed transitions: isomeric decay from ^{127}Sn ^{126}Sn
decay from (n,γ) reactions ●
background activity (511 keV, ^{40}K) ●



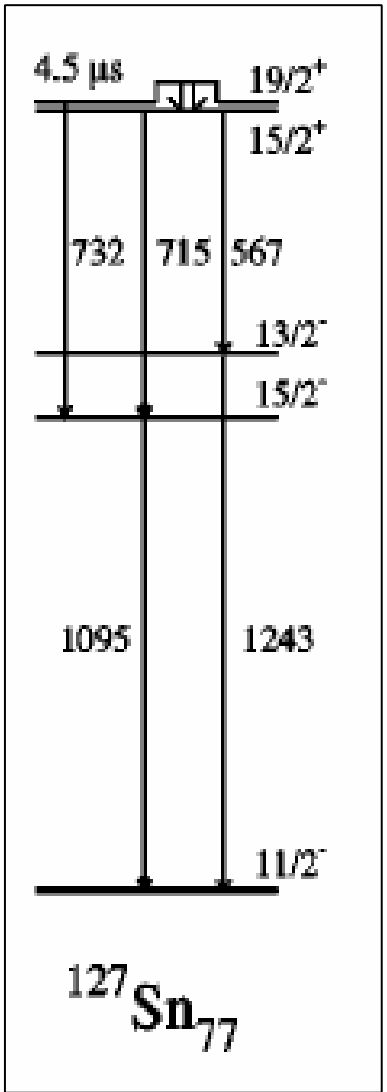
Time condition:
t > 3 μs



FIRST RESULTS

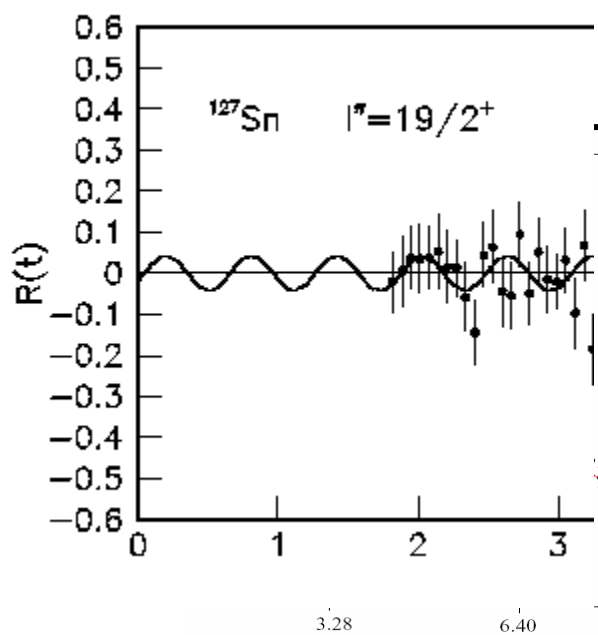
1. Spin-alignment in projectile fission and g-factors around ^{132}Sn 0 ^{127}Sn

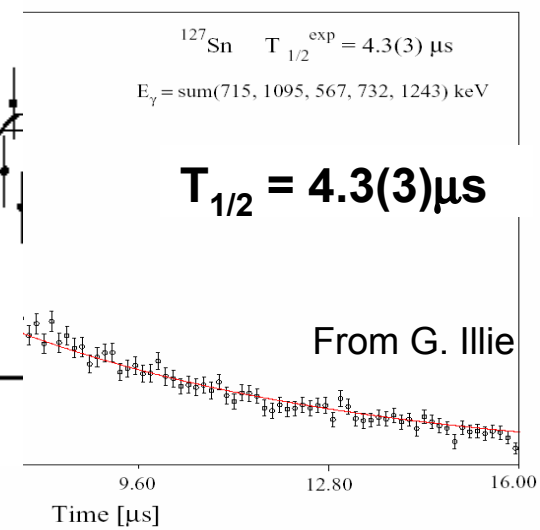
Pinston et al. PRC61 (2000)



statistics	Field up	Field down
715 keV E1? (15/2+ 0 15/2-)	12790	12937
1095 keV E2 (15/2- 0 11/2-)	**12137**	**12613**
567 keV E1 ? (15/2+ 0 13/2-)	3250	3401
		2407

0**R(t) analysis possible !**





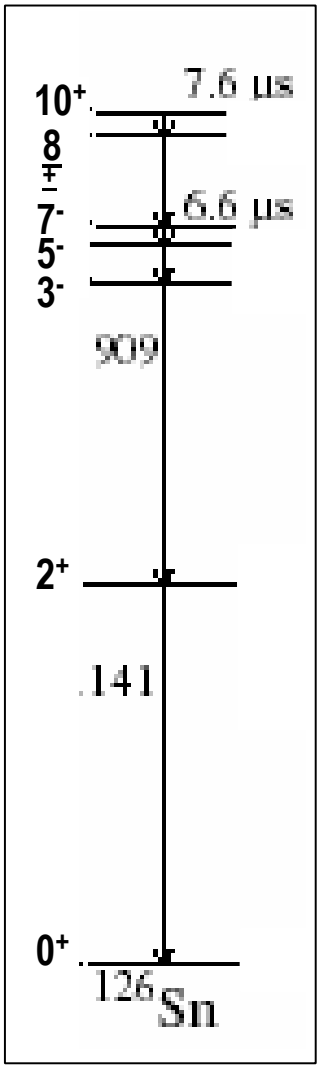
$T_{1/2}$ = 4.3(3)µs

From G. Illie

FIRST RESULTS

From G. Illie

Spin-alignment in projectile fission and g-factors around ^{132}Sn 0126Sn

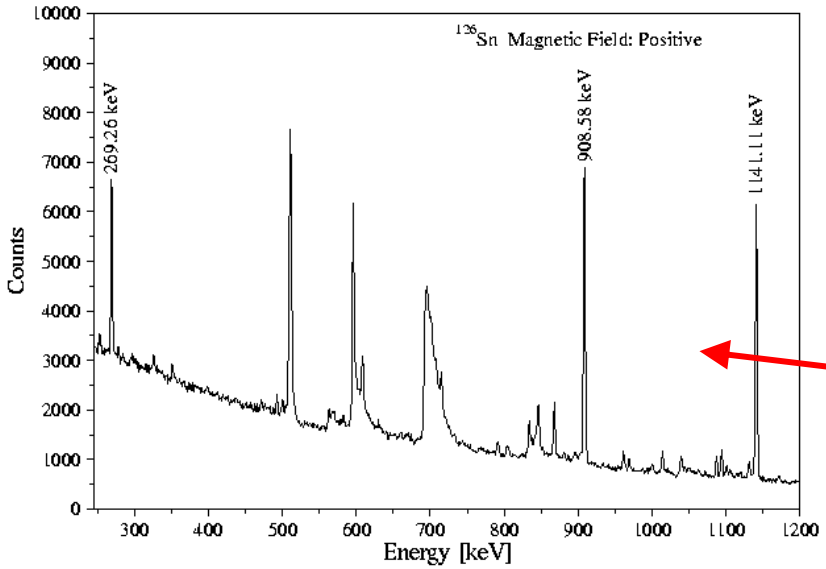


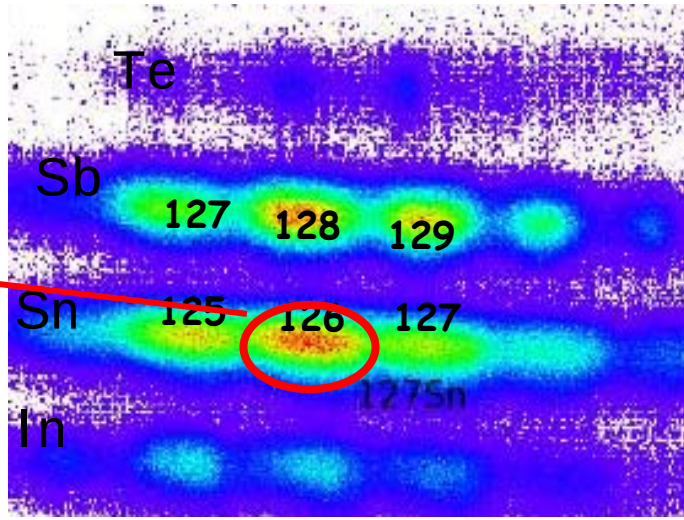
$\nu(h_{11/2})^n$ g~ -0.245

$\nu(h_{11/2}d_{3/2})$ g~-0.275

Statistics	Field up	Field down
1141 keV E2	30910	31000
909 keV E1?	31057	31264
269 keV E1	12451	12858

0R(t) analysis possible for each transition

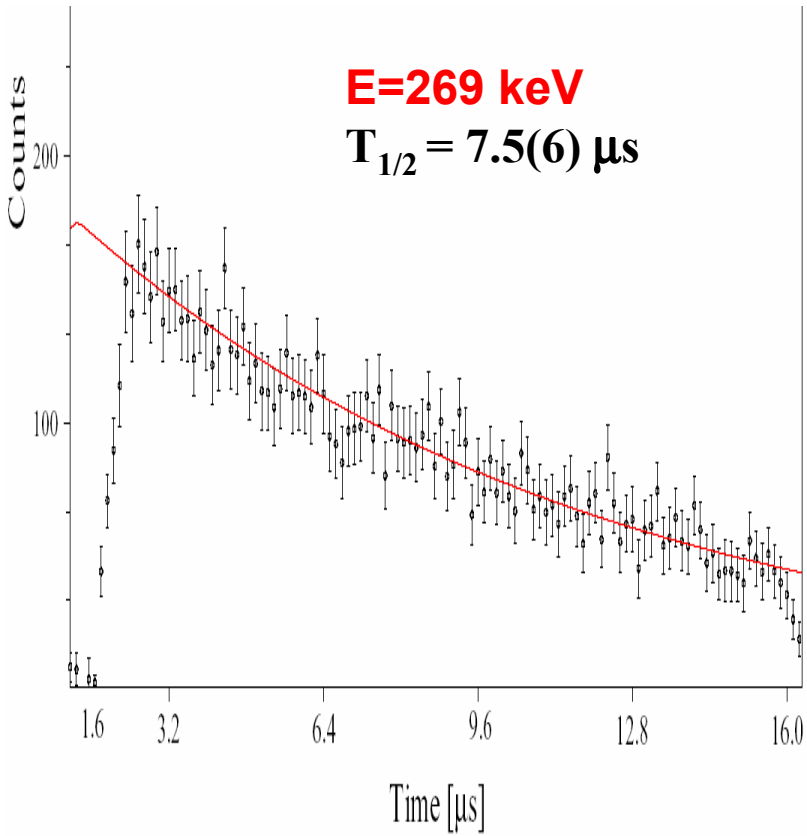


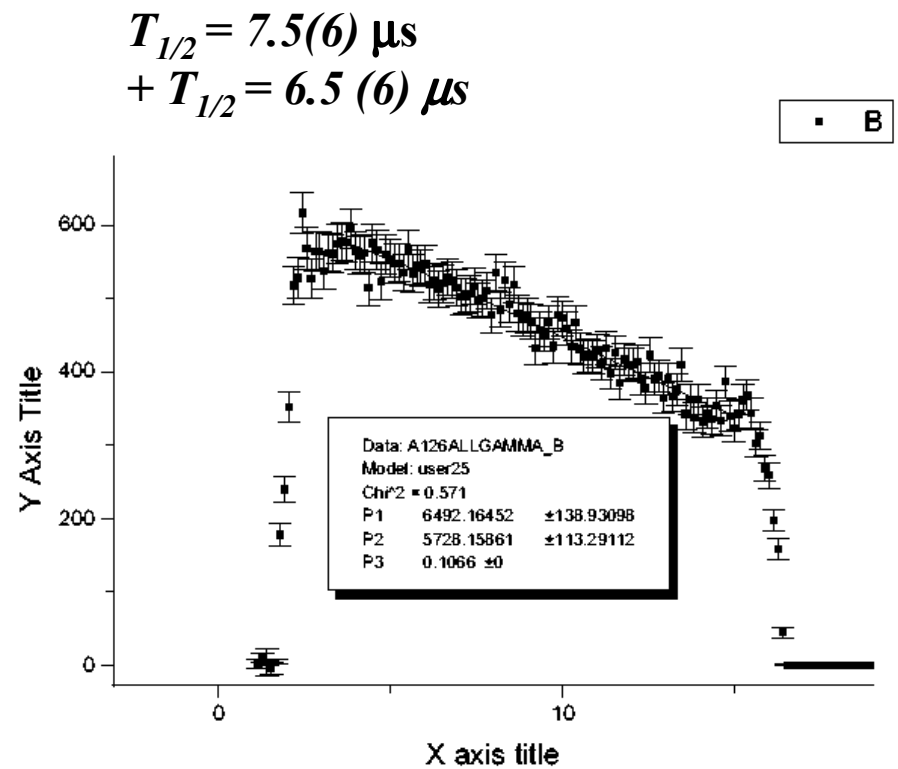


FIRST RESULTS

From G. Illie

1. Spin-alignment in projectile fission and g-factors around ^{132}Sn 0126Sn

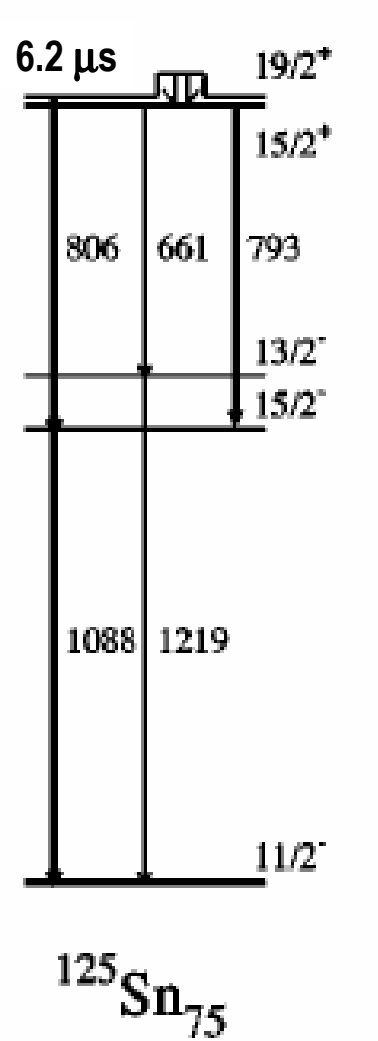




FIRST RESULTS

From G. Illie

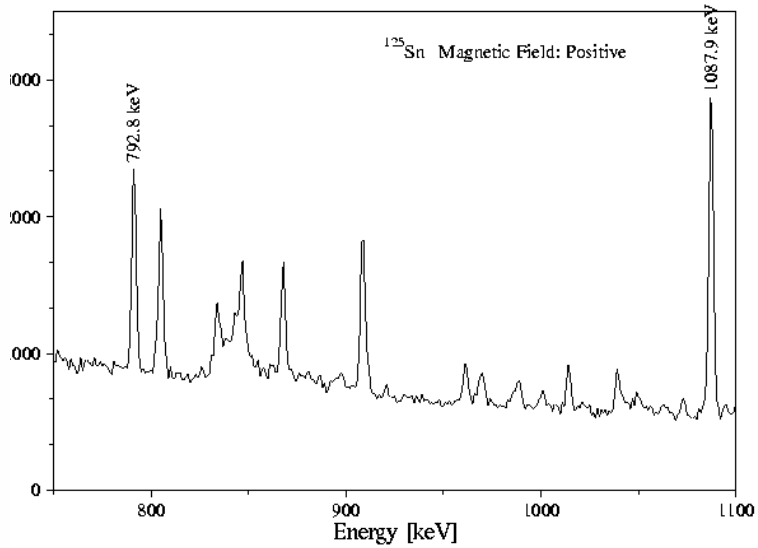
1. Spin-alignment in projectile fission and g-factors around ^{132}Sn 0125Sn

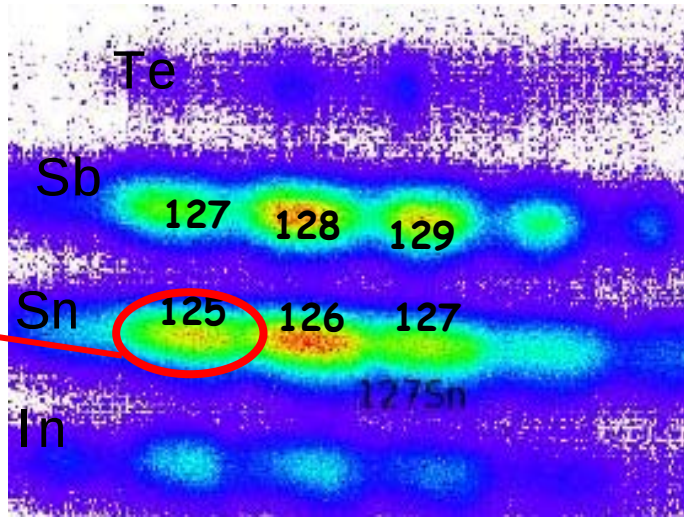


t>3 microsec

Statistics	Field up	Field down
806 keV M2	5497	5659
1088 keV E2	11962	12683
793 keV E1	6864	7472

0R(t) analysis possible !





FIRST RESULTS

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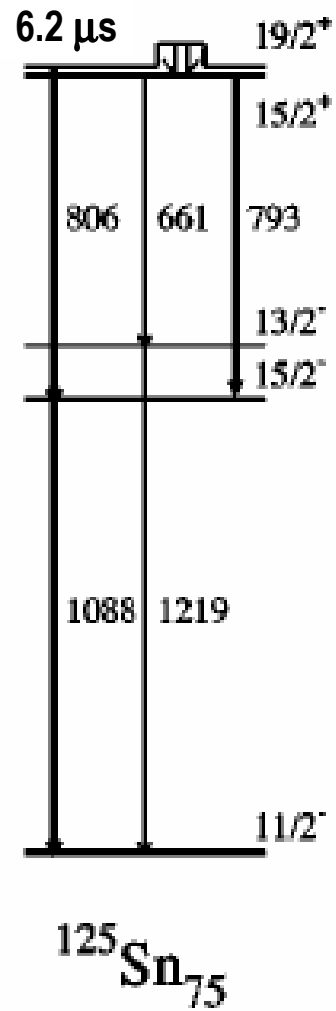
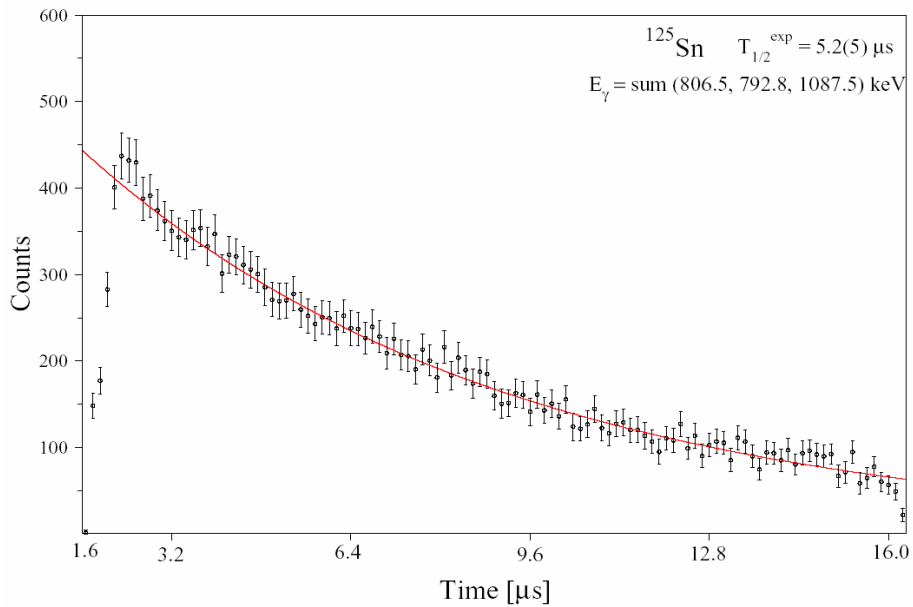
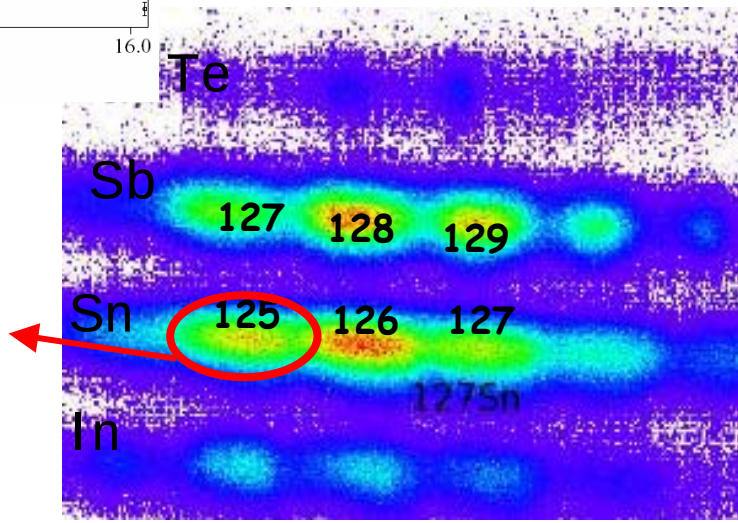


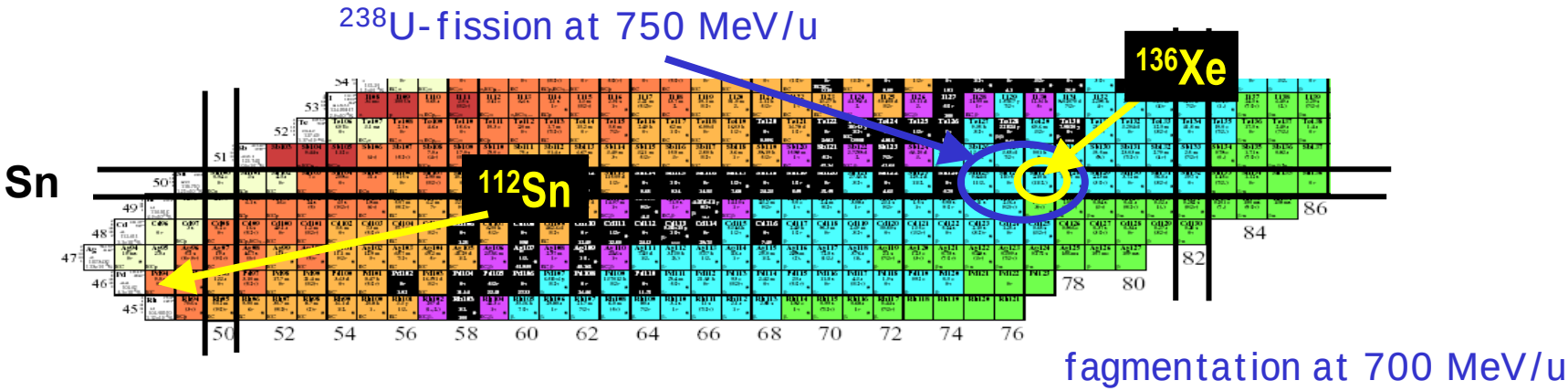


$T_{1/2} = 5.2(5)\ \mu s$



FIRST RESULTS

Spin-alignment and g-factors of isomers in ^{127,128}Sn from fragmentation of a ^{136}Xe beam. (Dimiter Balabanski and Michael Hass)

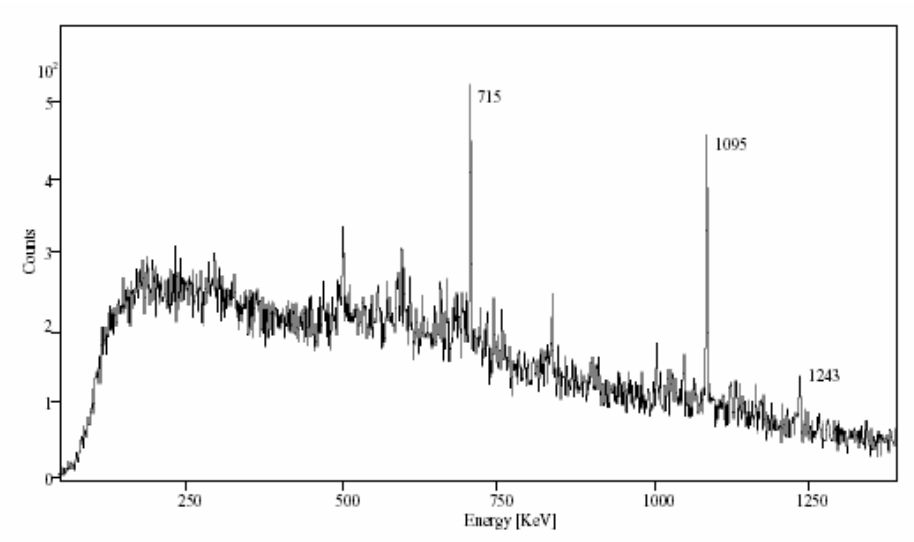


AIMS:

- **direct comparison of spin-alignment in fragmentation and in fission**
- **different applied field: two independent measurements of g-factor ^{127}Sn, 19/2$^+$ isomer**
- **g-factor and spin-alignment for ^{128}Sn**

FIRST RESULTS

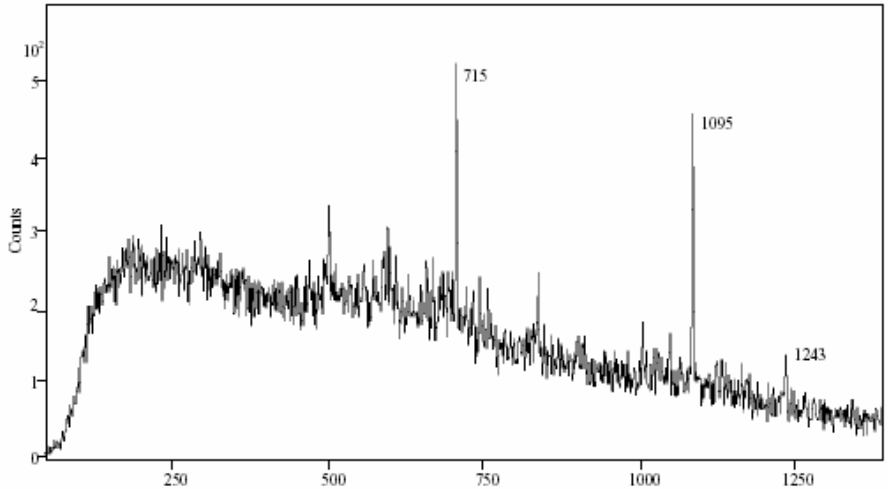
Spin-alignment and g-factors of isomers in ^{127,128}Sn from fragmentation of a ^{136}Xe beam. (Dimiter Balabanski and Michael Hass)



Statistics	Field up	Field down
715	28571	30427
1095	32056	34379
1243	5720	6309

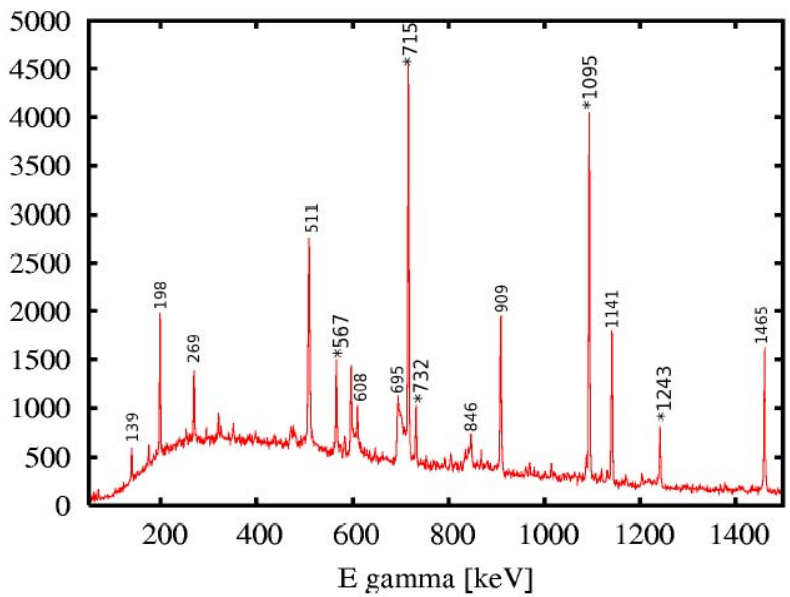
FIRST RESULTS

Spin-alignment and g-factors of isomers in ^{127,128}Sn from fragmentation of a ^{136}Xe beam. (Dimiter Balabanski and Michael Hass)



0In the fragmentation experiment:

- isotopes are better separated
- no neutron-induced reactions
- no 511 keV (neutron deficient)



^{127}Sn

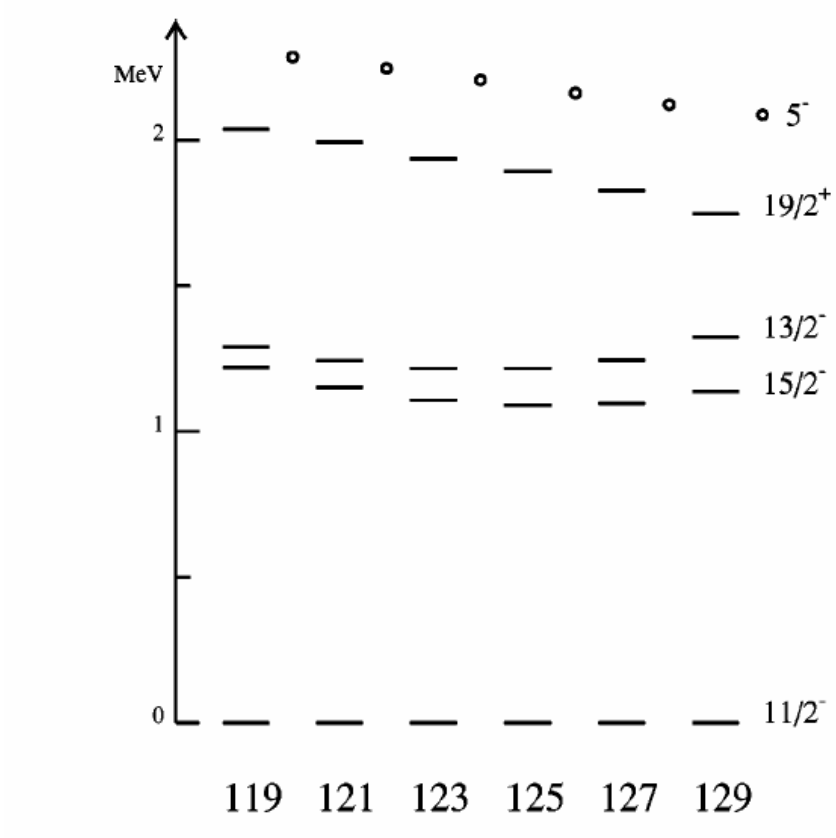
Time condition:
t > 3 μs

PRC61(2000) Pinston

What we hope to see

-$19/2^-$ isomers are n 5^-x $h_{11/2}$
5^- is not pure -admixture of $s_{1/2}$ and $d_{3/2}$
Predicted to change going from stability to neutron rich (Insolia et al.Nucl. Phys. A550 (1992) 34.) - hope to see this in g factors

Magnetic dipole operator in ^{132}Sn region -does it fit the theory? -in 208Pb region M1 operator couldn't be correctly reproduced from 1st principles.

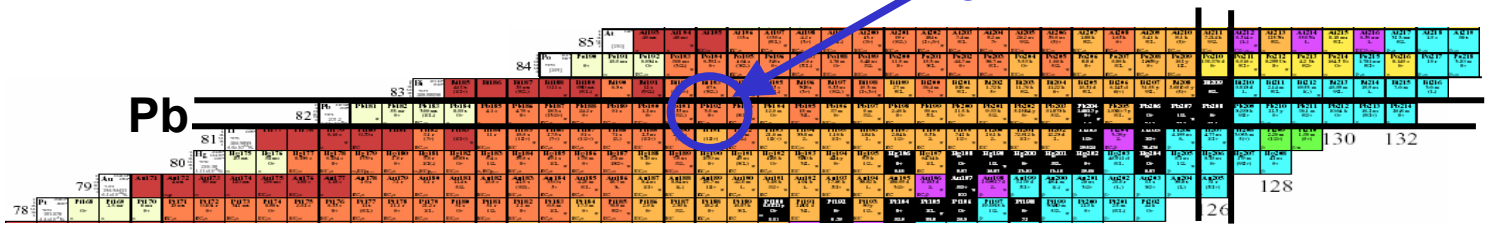


FIRST RESULTS

2. Spin-alignment and g-factor of isomers in the neutron deficient Pb-region.

(Adam Maj and Juergen Gerl)

^{238}U-fragmentation at 1 GeV/u

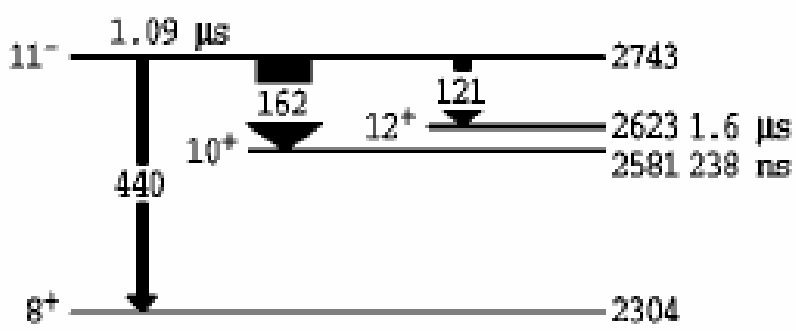


Total ion rate at S4 ≈ 30.000/spill

FIRST RESULTS

2. Spin-alignment and g-factor of isomers in the neutron deficient Pb-region.

(Adam Maj and Juergen Gerl)



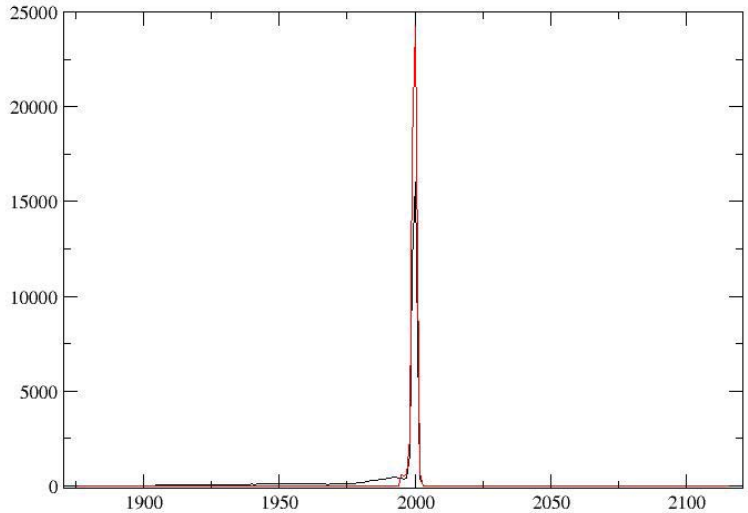
For E= 440 (E3!) 0 very good for R(t) analysis
and for the g-rays below 8+

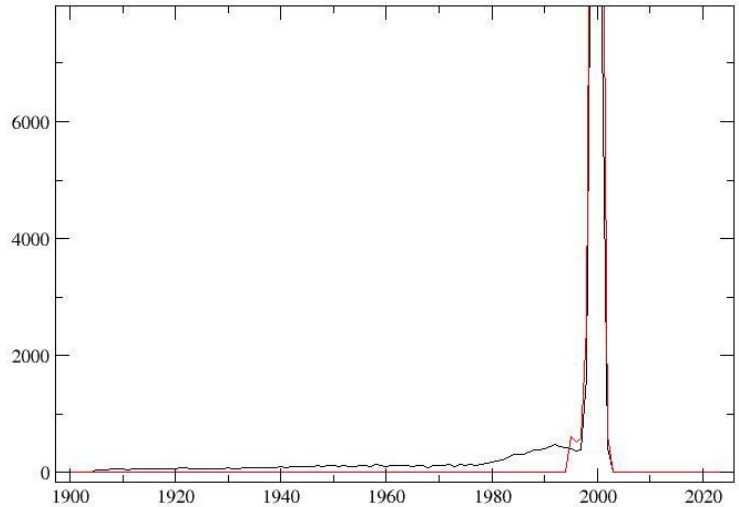
Conclusions

Hope to get g factors for 132Sn and 210Pb regions

Still need to improve parts of the analysis programs

Maybe results in the next few weeks





THE g-RISING core members:

1. **K.U. Leuven, Belgium:** **G. Neyens**, **N. Vermeulen**
2. **University of Sofia, Bulgaria:** **L. Atanasova, R. Lozeva (double affiliation with Leuven)**
3. **ILL Grenoble, France:** **G. Simpson**
4. **GSI-Darmstadt, Germany:** F. Becker, P. Bednarczyk (double affiliation with Krakow) , L. Caceres, P. Doornenbal, **J. Gerl,** M. Górska, I. Kojuharov, W. Prokopowicz, E. Werner-Malento, H.J. Wollersheim
5. **IKP Koeln, Germany:** **G. Illie**
6. **The Weizmann Institute, Israel: M. Hass**
7. **University of Camerino, Italy: D.L. Balabanski (double affiliation with INRNE, Sofia, Bulgaria)**
8. **IFJ-PAN Krakow, Poland:** J. Gr?bosz, **M. Kmiecik**, **A. Maj**
9. **Warsaw University, Poland:** M. Pf?tzner
10. **University of Surrey, UK:** Zs. Podolyàk, J. Walker, S. Pietri

THE g-RISING COLLABORATION
For U-fission experiment

1. K.U. Leuven, Belgium: M. De Rydt, S. Mallion, **G. Neyens**, K. Turzó, **N. Vermeulen, R. Lozeva (double affiliation with University Sofia)**
2. University of Sofia, Bulgaria: **L. Atanasova**
3. ILL Grenoble, France: **G. Simpson**
4. CEA, Bruyères le Chatel, France: J.M. Daugas, O. Perru
5. GSI-Darmstadt, Germany: F. Becker, P. Bednarczyk (double affiliation with Krakow), L. Caceres, P. Doornenbal, **J. Gerl,** M. Górska, I. Kojuharov, N. Kurz, W. Prokopowicz, T.R. Saitoh, H. Schaffner, E. Werner-Malento, H.J. Wollersheim
6. IKP Koeln, Germany: J. Jolie, **G. Illie**
7. The Weizmann Institute, Israel: S. Chamoli, **M. Hass**
8. University of Camerino, Italy: D.L. Balabanski (double affiliation with INRNE, Sofia, Bulgaria)
9. IFJ-PAN Krakow, Poland: J. Gr?bosz, **M. Kmiecik**, **A. Maj**
10. Warsaw University, Poland: M. Pf?tzner
11. NIPNE, Bucharest, Romania: M. Ionescu-Bujor
12. Universidad Autonoma de Madrid, Spain: A. Jungclaus
13. University of Surrey, UK: Zs. Podolyàk, J. Walker and C. Brandau.

THE g-RISING COLLABORATION
For U-fragmentation experiment

1. K.U. Leuven, Belgium: **G. Neyens**, **N. Vermeulen**
2. University of Sofia, Bulgaria: **L. Atanasova,** P. Detistov, **R. Lozeva (double affiliation with Leuven)**
3. ILL Grenoble, France: **G. Simpson**
4. CSNSM Orsay, France: G. Georgiev (was he present ??)
5. ISKP Bonn, Germany: S Chmel
6. GSI-Darmstadt, Germany: F. Becker, P. Bednarczyk (double affiliation with Krakow), L. Caceres, P. Doornenbal, **J. Gerl,** H. Grawe, M. Górska, I. Kojuharov, N. Kurz, W. Prokopowicz, T.R. Saitoh, H. Schaffner, E. Werner-Malento H.J. Wollersheim
7. IKP Koeln, Germany: **G. Illie**
8. ATOMKI, Debrecen, Hungary: A. Krasznahorkay
9. The Weizmann Institute, Israel: S. Chamoli, **M. Hass**, **S. Lakshmi**
10. University of Camerino, Italy: D.L. Balabanski (double affiliation with INRNE, Sofia, Bulgaria), G. Lo Bianco, A. Saltarelli
11. LNL Legnaro, Italy: J.J. Valente-Dubon
12. University of Milano, Italy: F. Camera, G. Benzoni, N. Blasi, F. Crespi, D. Montanari, O. Wieland
13. INFN-Prugia, Italy: K. Gladnishki
14. IFJ-PAN Krakow, Poland: J. Gr?bosz (double affiliation with GSI) , **M. Kmiecik**, **A. Maj**, K. Mazurek, W. M?czy?ski, S. Myalsky, J. Stycze?, M. Zi?bli?ski
15. Jaggielonian University, Krakow, Poland: R. Kulessa;
16. Warsaw University, Poland: M. Pf?tzner
17. NIPNE, Bucharest, Romania: M. Ionescu-Bujor
18. Universidad Autonoma de Madrid, Spain: A. Jungclaus
19. Univerity of Lund, Sweden: R. Hoishen, D. Rudolf
20. University of Surrey, UK: Zs. Podolyàk, J. Walker, S. Pietri and C. Brandau.

THE g-RISING COLLABORATION
For Xe-fragmentation experiment

1. K.U. Leuven, Belgium: **G. Neyens**, **N. Vermeulen**
2. University of Sofia, Bulgaria: **L. Atanasova,** P. Detistov, **R. Lozeva (double affiliation with Leuven)**
3. ILL Grenoble, France: **G. Simpson**
4. CSNSM Orsay, France: G. Georgiev
5. GSI-Darmstadt, Germany: F. Becker, P. Bednarczyk (doube affiliation with Krakow), L. Caceres, P. Doornenbal, **J. Gerl,** H. Grawe, M. Górska, I. Kojuharov, N. Kurz, W. Prokopowicz, T.R. Saitoh, H. Schaffner, S.Tachenov, E. Werner-Malento H.J. Wollersheim
6. IKP Koeln, Germany: **G. Illie**, A. Blazhev
7. IKHP Rossendorf, Germany: R. Schwengner, G. Russev
8. The Weizmann Institute, Israel: S. Chamoli, **M. Hass**, **S. Lakshmi**
9. University of Camerino, Italy: D.L. Balabanski (double affiliation INRNE, Sofia, Bulgaria), G. Lo Bianco, A. Saltarelli
10. LNL Legnaro, Italy: J.J. Valente-Dubon
11. University of Milano, Italy: F. Camera, A. Bracco, G. Benzoni, N. Blasi, F. Crespi, D. Montanari, O. Wieland
12. U. Padova and INFN Padova, Italy: D. Bazzacco, E. Farnea
13. INFN-Prugia, Italy: K. Gladnishki
14. IFJ-PAN Krakow, Poland: J. Gr?bosz (Double affiliation with GSI), **M. Kmiecik**, **A. Maj**
15. Jaggielonian University, Krakow, Poland: R. Kulessa;
16. Warsaw University, Poland: M. Pf?tzner
17. NIPNE, Bucharest, Romania: M. Ionescu-Bujor
18. Universidad Autonoma de Madrid, Spain: A. Jungclaus,
19. Univerity of Lund, Sweden: C. Fahlander, R. Hoishen, D. Rudolf
20. University of Surrey, UK: Zs. Podolyàk, J. Walker, S. Pietri and C. Brandau.

A Clover Pool for Stopped Beams?

- Need in the communtiy for a portable, compact, efficient Ge array for stopped beams (isomers, beta decay, isomeric moments)
- 4 Clover detectors -higher efficiency than 60% phase-1 detectors
- Use at GANIL, ALTO, ISOLDE, ILL