From g-RISING @GSI to g-SPEC @FAIR

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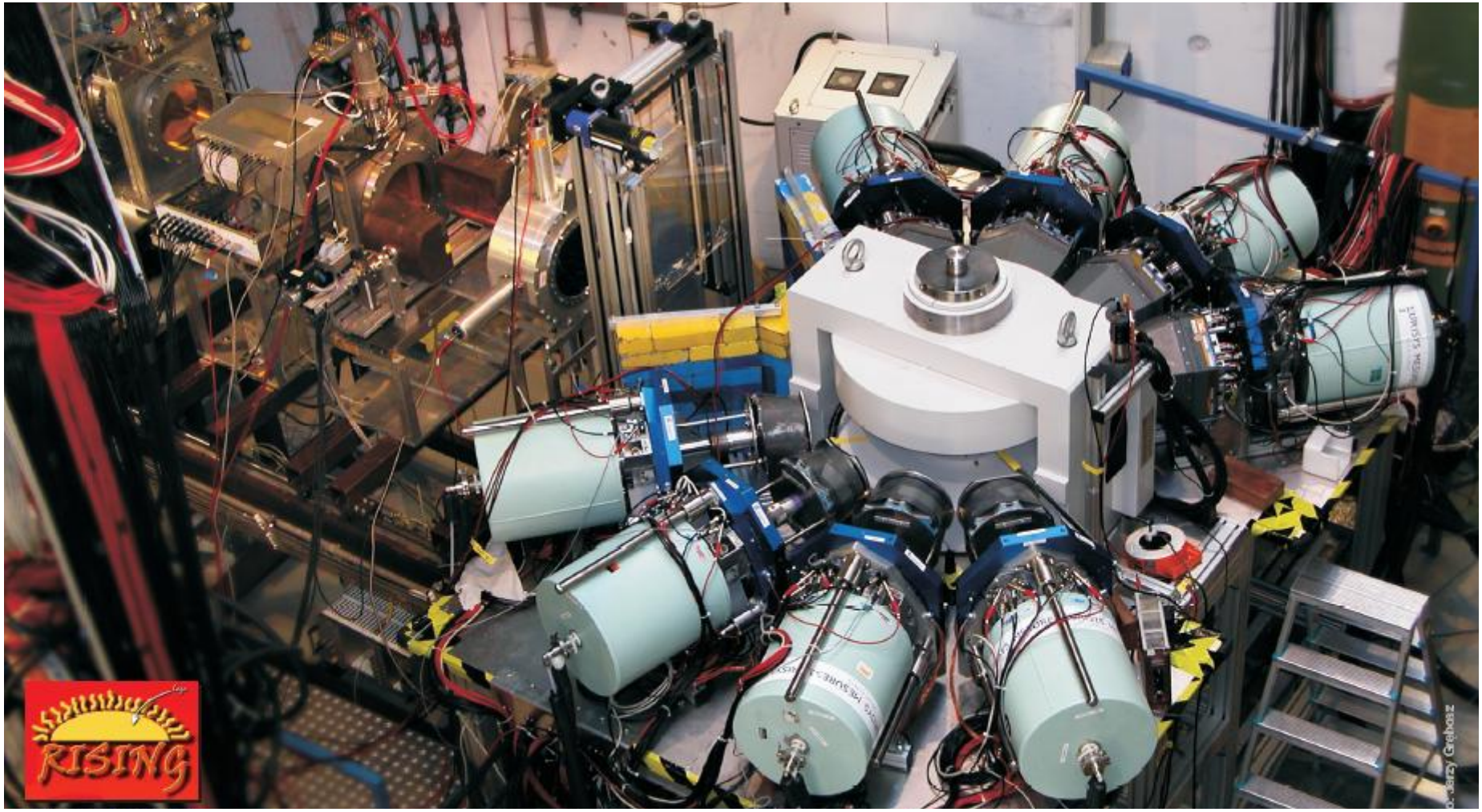
CNRS/IN2P3

Moments with DESPEC ?



FAIR-France meeting, 17-18 May 2017, Orsay

GOALS OF THE g-FACTOR CAMPAIGN

GOAL 1:

➔ demonstrate that **fully-stripped isomeric beams of heavy elements** (A~200) produced by **fragmentation of a relativistic ^{238}U beam**, remain fully stripped and thus preserve their reaction-induced spin- alignment up to the implantation point.

GOAL 2:

➔ demonstrate that **isomeric beams of neutron-rich fission fragments**, produced by **relativistic fission of a ^{238}U beam**, are spin-aligned.

GOAL 3:

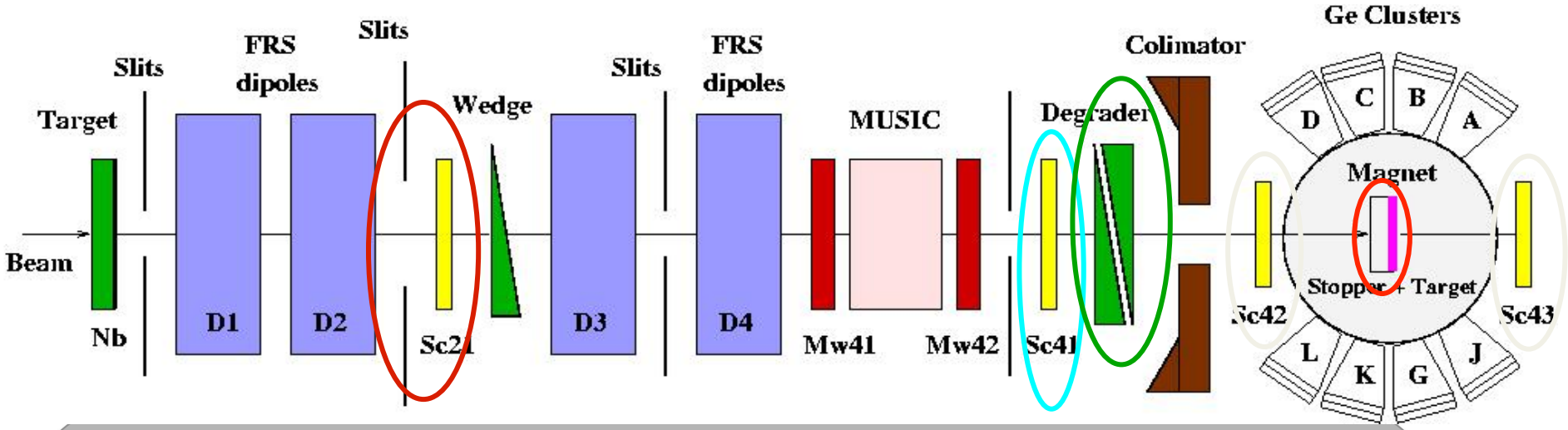
➔ study **g-factors of isomeric states towards doubly-magic ^{132}Sn**, in order to test shell model interactions and to study the evolution of shell structure far from stability.

➔ **compare** the spin-alignment from fission and fragmentation

GOAL 4:

➔ **search for new isomers** – structure in the neutron **^{132}Sn isotopes produced by fission and fragmentation**

Experimental set-up at FRS @ GSI



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

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

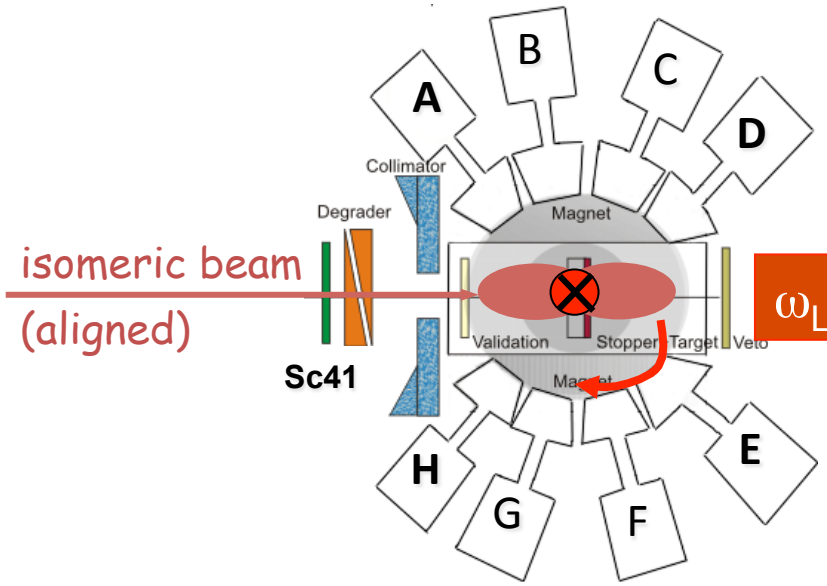
Beam energy after Al degrader > 300 MeV/u → to remain fully stripped

Implantation: plexiglass degrader + 2 mm Cu (annealed)

SC42 and SC43 validates the event

G. Neyens et al, Act. Phys. Pol. B38, 1237 (2007)

Experimental set-up and method: Time Differential Perturbed Angular Distribution (TDPAD)



Measure isomeric γ–decay

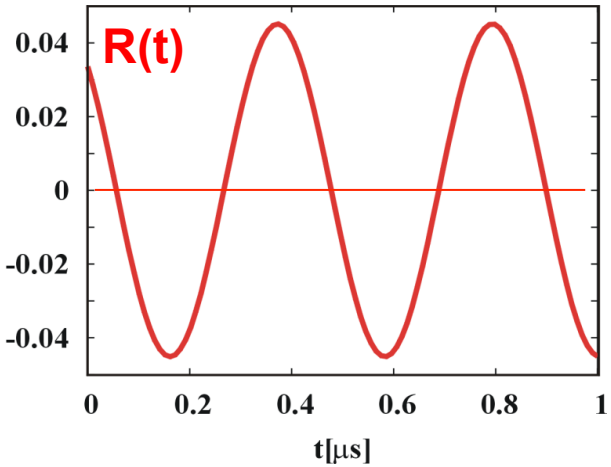
$I(\theta,t) \sim e^{-t/\tau}(1-A\,P_2[\cos(\theta-\omega_L t)])$

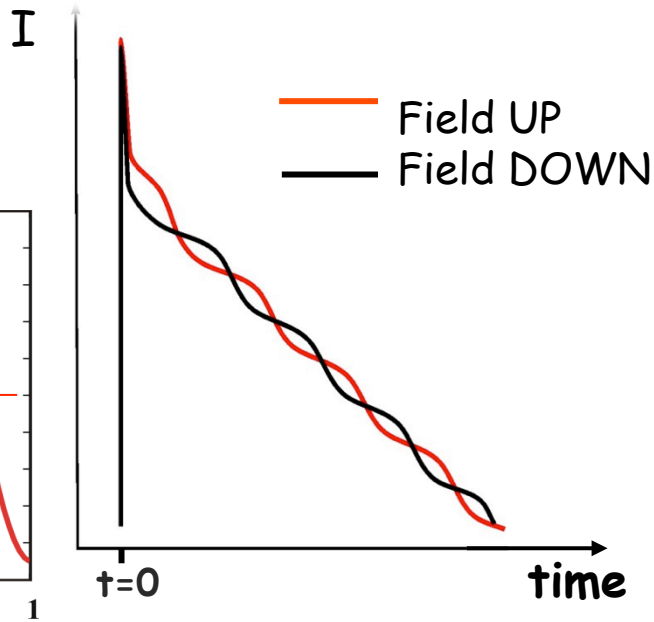
$\omega_L = -g\mu_N B/\hbar$

Start (t=0): ion arrives in Sc41
Stop: γ detected in 1 … 8
time range: 15 μs

Combine field up/down spectra → eliminate exponential decay (= R(t) curve)

Amplitude ~ alignment
Period ~ ω_L ~ g



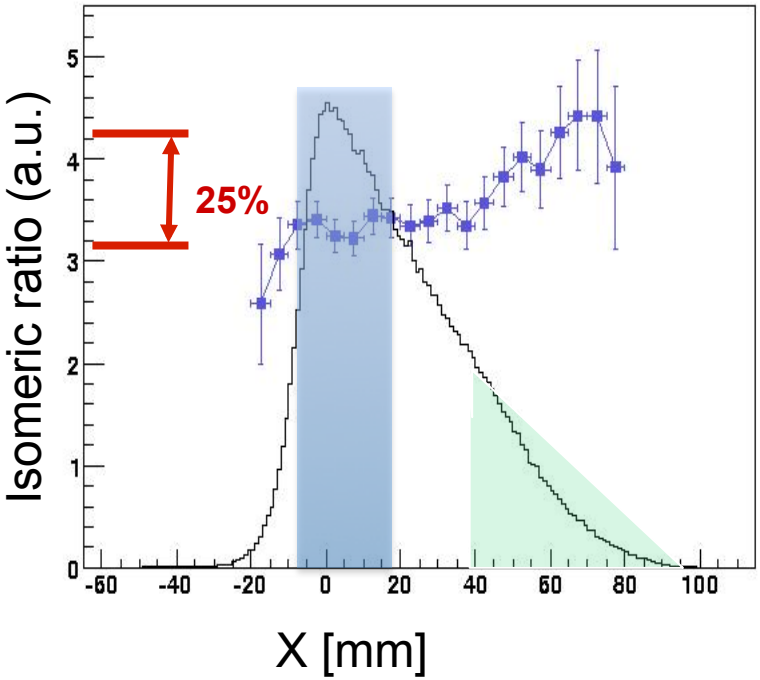


Momentum selection in fragmentation/ fission

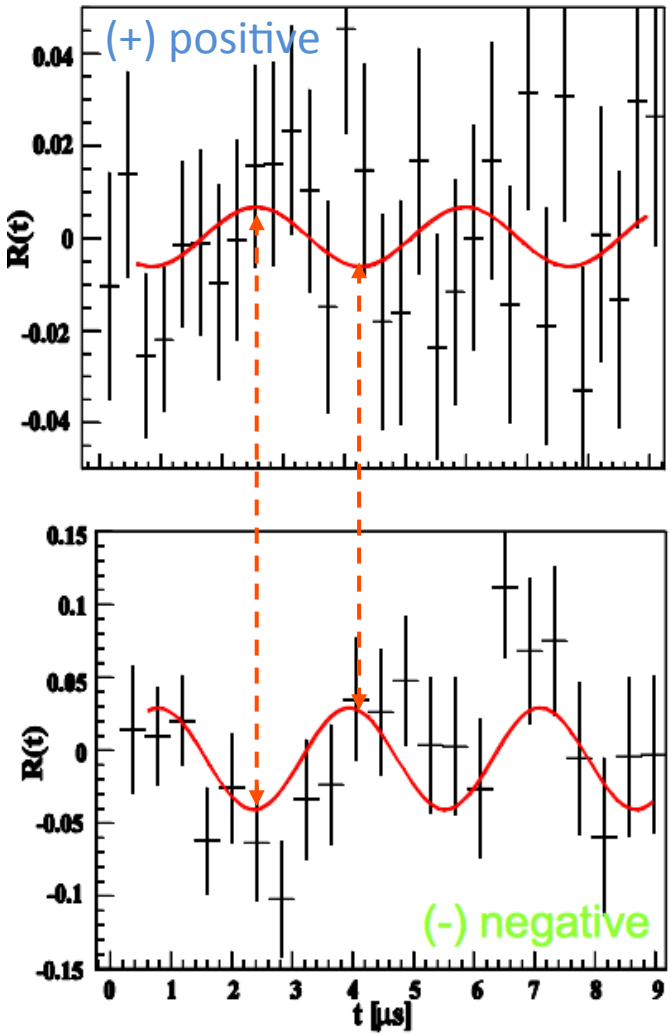
Momentum spead is narower < 3% (Δp/p)
-the selection is done by slits or by ion correlation
-measured by position sensitive scintillator

@ FRS using **relativistic fragmentation**:
^{136}Xe (600 MeV/u) → ^{127}Sn

Momentum selection in fragmentation is crucial for the alignment !



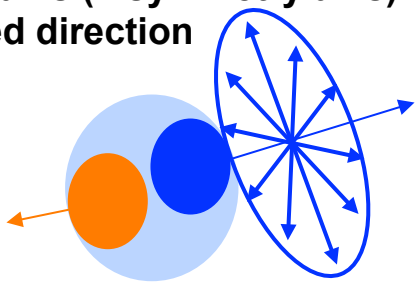
L. Atanasova



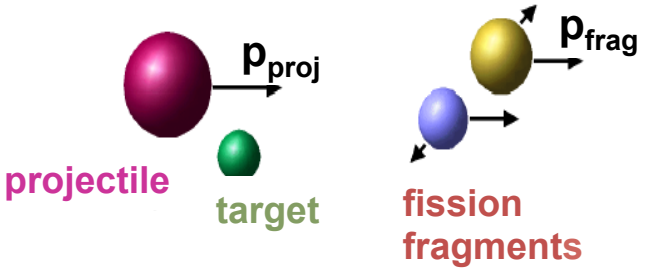
Challenge: spin-alignment in relativistic fission : never observed

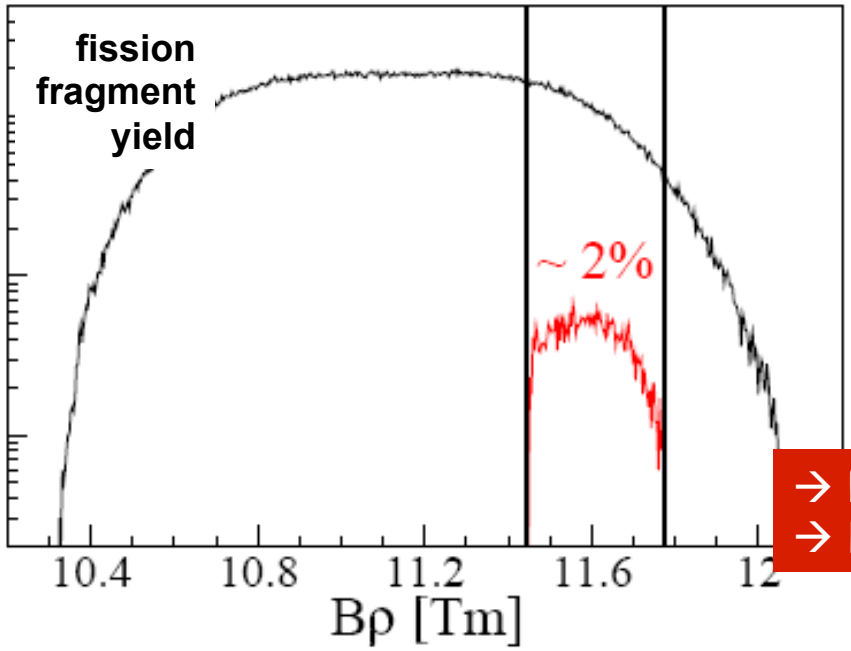
In spontaneous fission: Wilhelmy et al, PRC5 (1972)

- → **spins perpendicular to emission axis (= symmetry axis)**
- → **selection of emitted ions in a fixed direction**
- → **alignment up to 50%**



In relativistic fission FRS:
Moving projectile is fissioning:





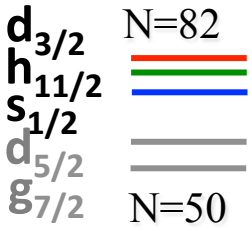
Fragments with higher/lower velocity
= fission fragment emitted
along beam axis

→ Oblate alignment expected

→ broad momentum spread in fission (~ 10%)
→ FRS momentum slits can remain fully open

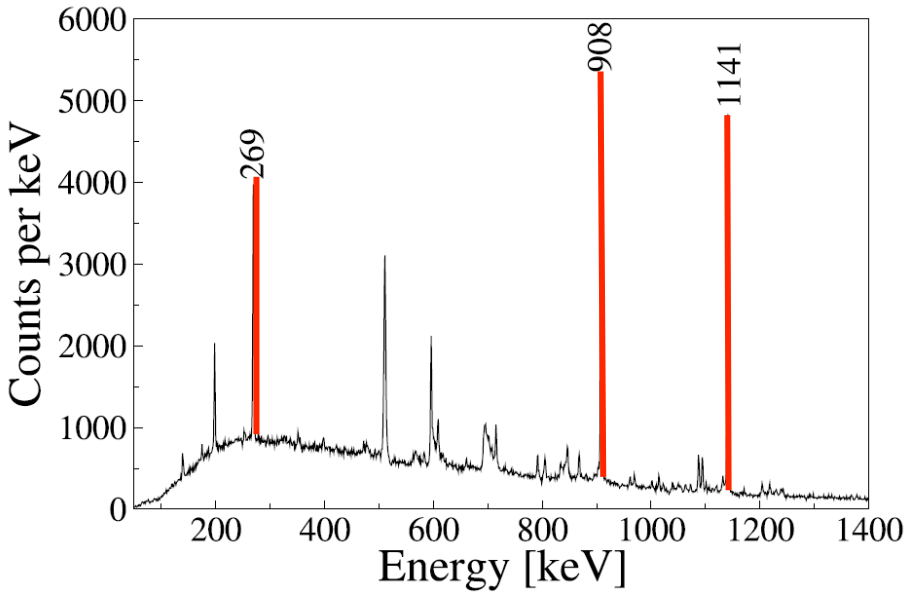
G. Ilie et al, PLB 687 (2010) 305

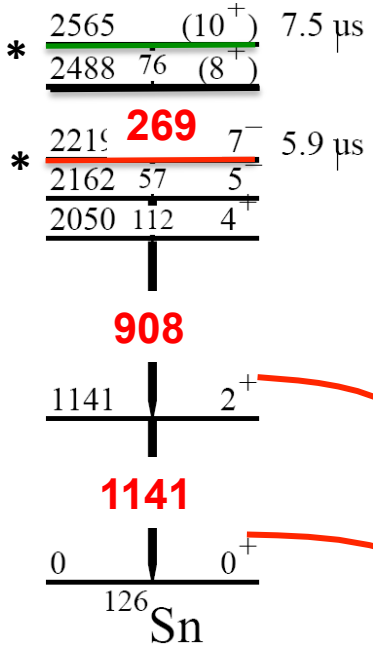
measured for the first time in g-RISING !



RESULTS: ^{126}Sn: R(t) analysis from fission experiment

G. Ilie et al, PLB 687 (2010) 305





Empirical g-factors :

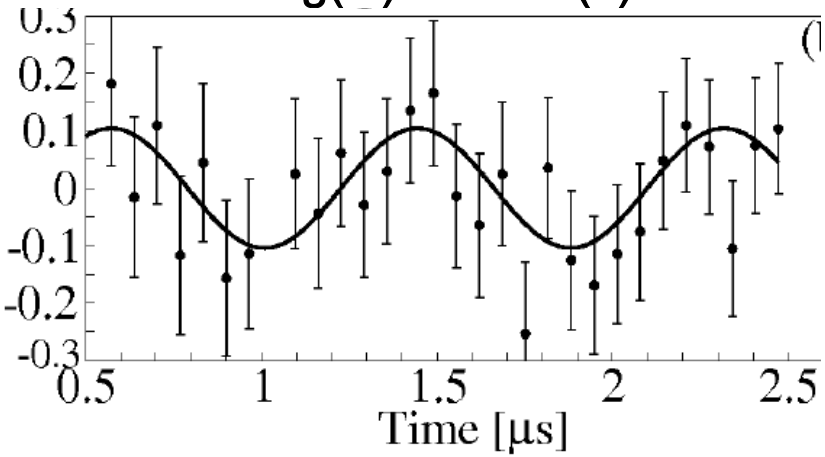
$\nu(h_{11/2})^{-2}$ $g(10^+) \sim -0.24$

$\nu(h_{11/2}^{-1}d_{3/2}^{-1})$ $g(7^-) \sim -0.11$

$g(^{130}Sn,3/2-)$	$g(^{126}Sn,11/2-)$
−0.0756(10)	−0.0826(10)
SM −0.076	−0.077
	additivity

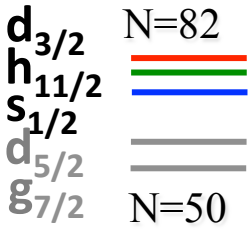
→g-factor very sensitive to mixing with particular configurations

$g(7^-)$= -0.098(7)



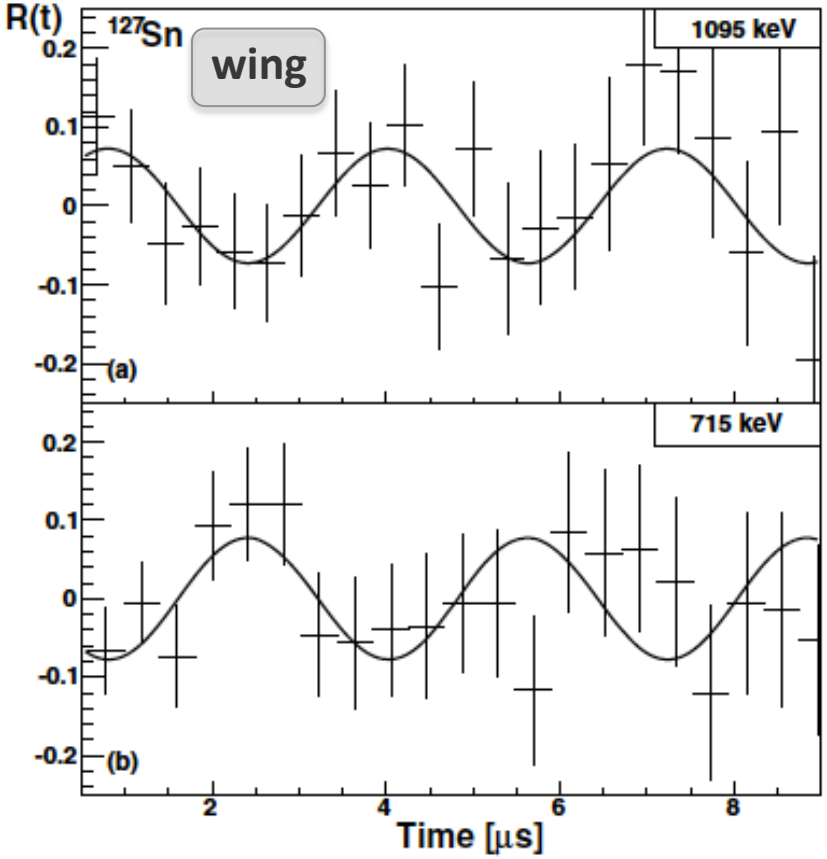
➔ Alignment of 18(8)% observed !

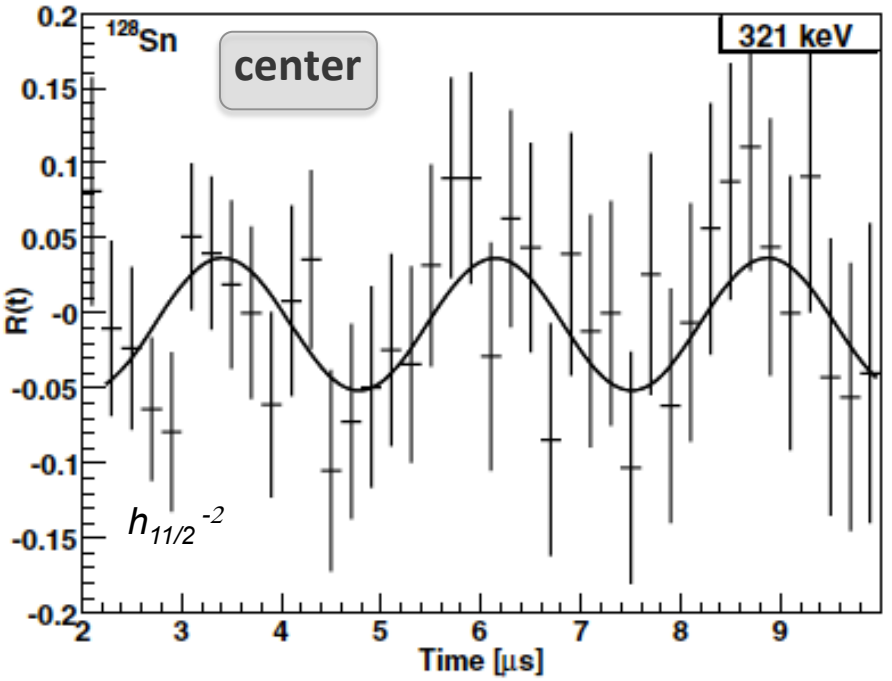
First observation of spin-alignment in relativistic fission !



RESULTS: Study of g-factors in isomers approaching ^{132}Sn using fragmentation reactions

*L. Atanasova et al, EPL **91** (2010) 42001*





−19(5)% $g(19/2^+; {}^{127}Sn) = -0.17(2)$

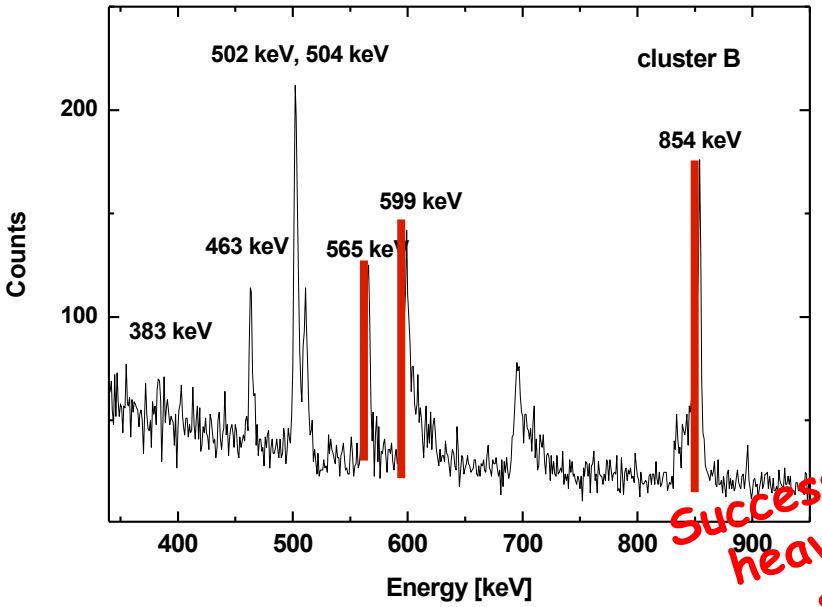
SM: g-free : −0.212 g-eff: −0.148

+12(4)% $g(10^+; {}^{128}Sn) = -0.20(4)$

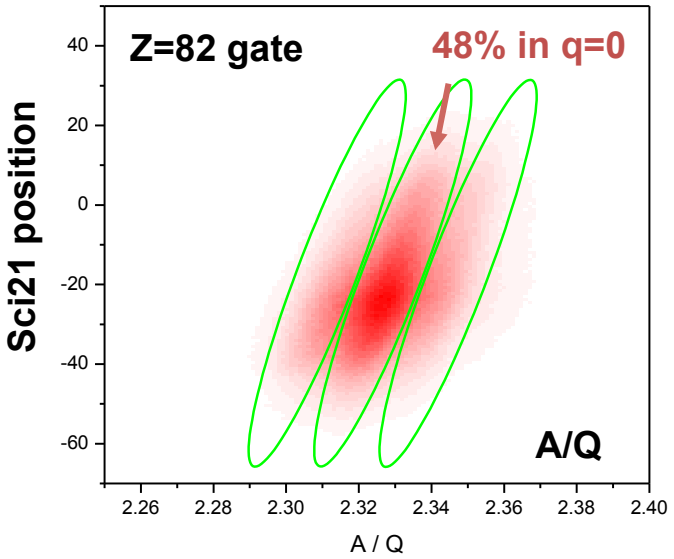
SM: g-free : −0.359 g-eff: −0.251

s.p. config.	g_{exp}	$19/2^+$ config.	g_{emp}
$\nu(1h_{11/2}^{-1})$	−0.242(1) [21]		
$\nu(3s_{1/2}^{-1})$	−2.05 [22]	$\nu(3s_{1/2}^{-1}1h_{11/2}^{-2})$	−0.156
$\nu(2d_{3/2}^{-1})$	+0.505(3) [21]	$\nu(2d_{3/2}^{-1}1h_{11/2}^{-2})$	−0.266
$\nu(2d_{5/2}^{-1})$	−0.432(2) [23]	$\nu(2d_{5/2}^{-1}1h_{11/2}^{-2})$	−0.241
$\nu(1g_{7/2}^{-1})$	+0.195(3) [22]	$\nu(1g_{7/2}^{-1}1h_{11/2}^{-2})$	−0.230

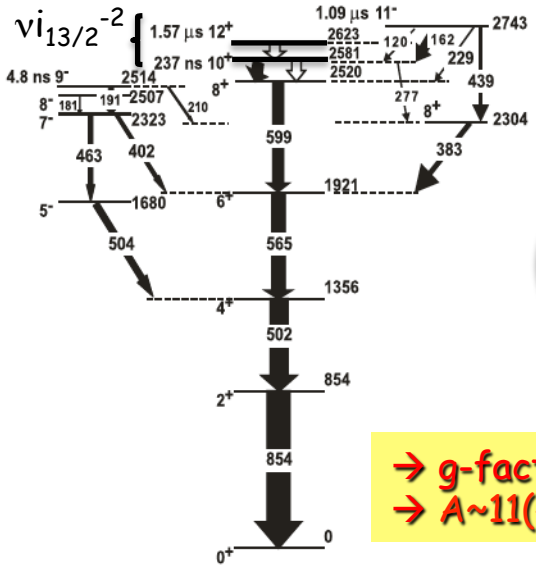
RESULTS: ^{192}Pb: R(t) analysis from U-fragmentation



M. Kmiecik et al, EPJA 45, 153-158 (2010)

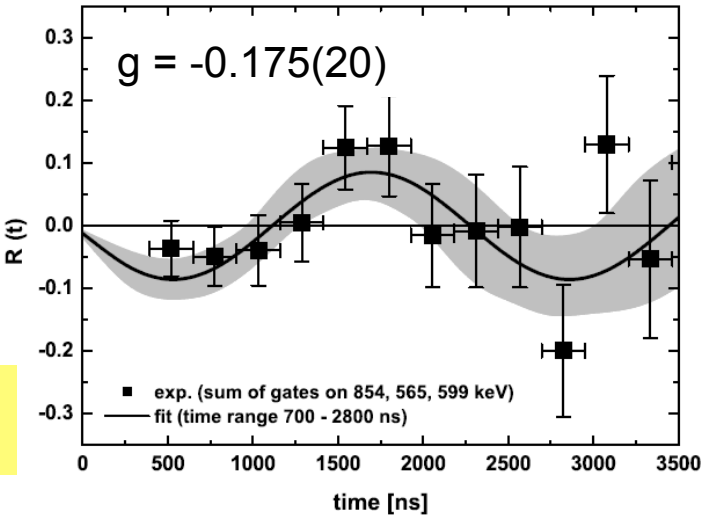


Success to maintain heavy ions fully stripped !



Improve result: gate on q=0 fragments only !

$I^{\pi}=12^{+}$ isomer
$T_{1/2}$= 1.54(9) μs
g_{FE} = -0.173(2)

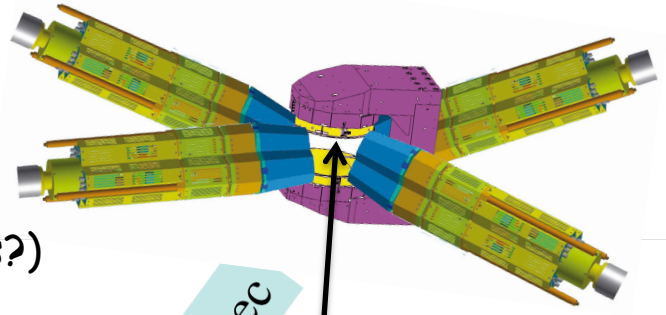


→ g-factor in agreement with earlier value
→ A~11(4)% → FEASIBILITY PROVEN

Possible continuation @FAIR…

-> similar arrangement @Super-FRS needed (4-6-8 Ge detectors)

->> detectors (Clusters, DEGAS, others?)
->> support table (arrangement)
->> electro magnet (C, solenoid, split..)
->> ancillary detectors (for high B)
->>…



The g-RISING collaboration

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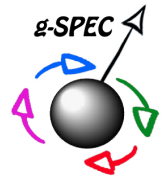
23. U.Surrey, UK: Zs. Podolyàk, J. Walker, S. Pietri and C. Brandau

g-SPEC collaboration is open to everyone…



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