Física Nuclear
Nuclear Physics

Instituto de Estructura de la Materia – Consejo Superior de Investigaciones Científicas

Calibration of the transient field strength experienced by heavy ions recoiling through ferromagnetic hosts at relativistic energies

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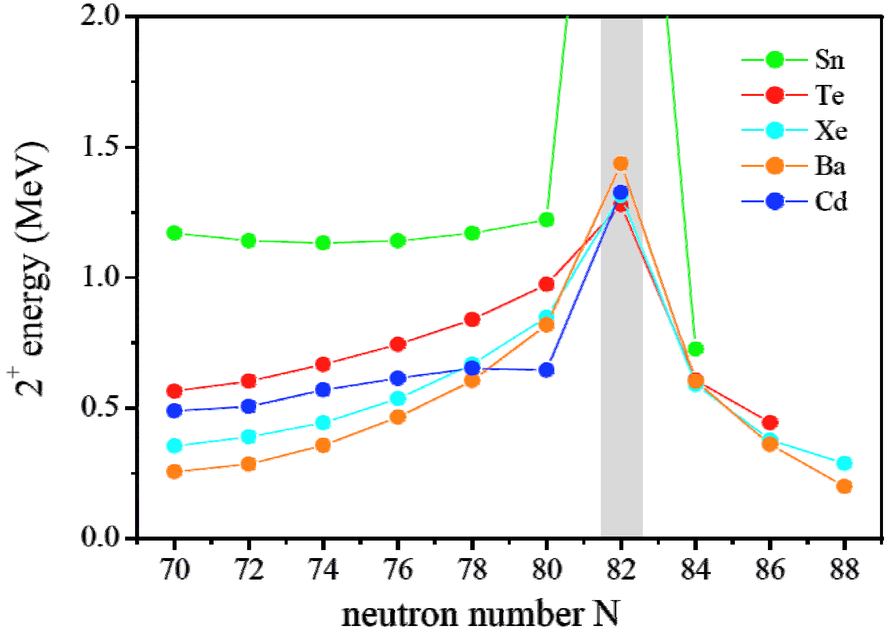
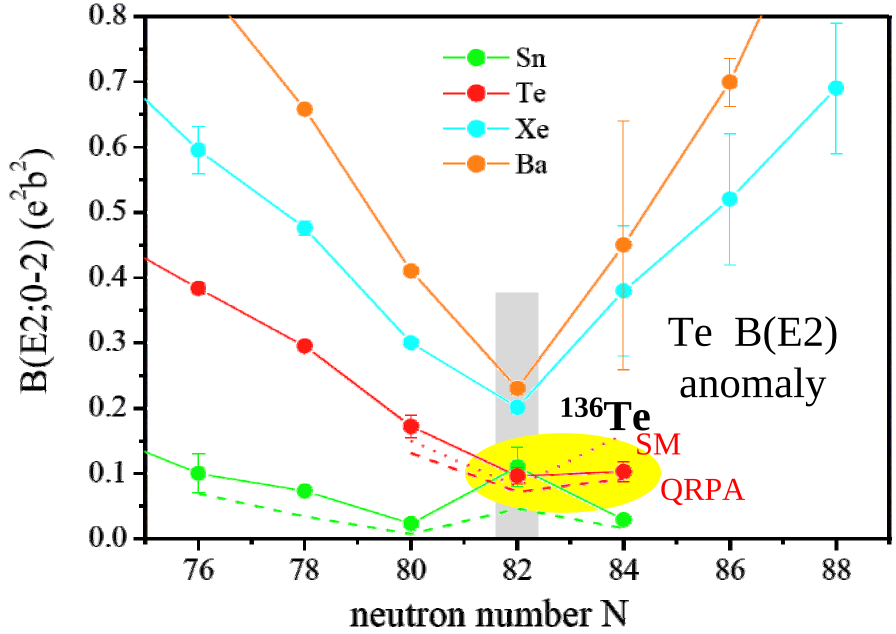
FRS User Meeting November 8/9, 2010

The anomalous behaviour of B(E2) in the Te isotopes





slight E(2$^+$) and B(E2) asymmetries with respect to N=82

E(2$^+$) for N=82+x < E(2$^+$) for N=82-x

B(E2) for N=82+x > B(E2) for N=82-x

except for the Te isotopes !

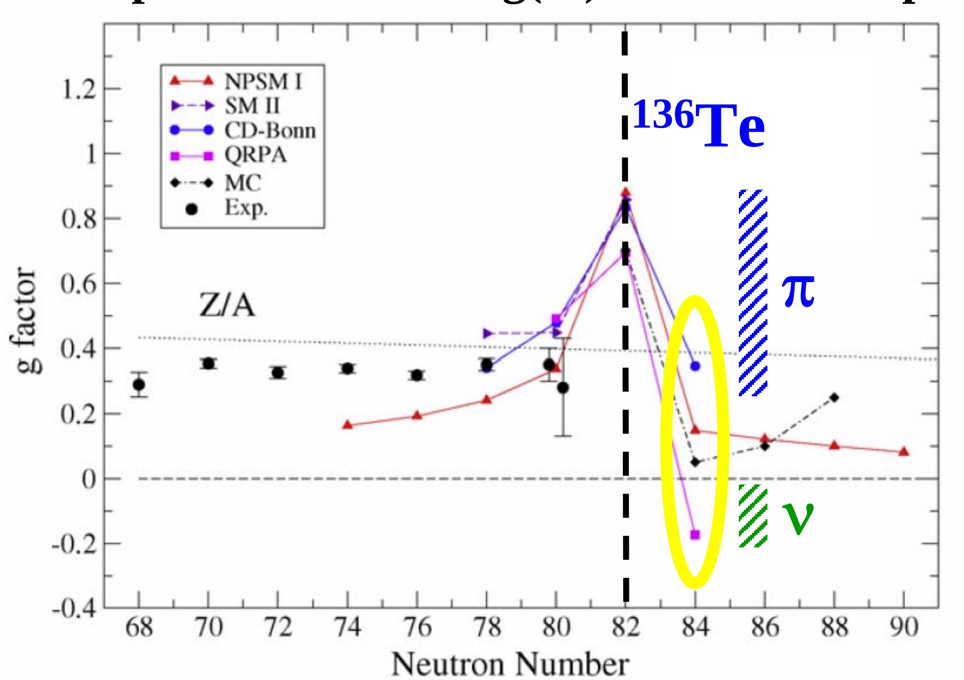
$$E(2_1^+)B(E2\uparrow) = \frac{2.57Z^2}{A^{2/3}}\left(1.288 - 0.088(N-\bar{N})\right) \quad \text{with} \quad \bar{N} = \frac{A}{2}\frac{1.0070 + 0.0128A^{2/3}}{1 + 0.0064A^{2/3}}$$

Habs' factor

Raman's version of Grodzins' formula

Why to measure magnetic moments of 2⁺ states ?

Exp. and theoretical g(2⁺) in Te the isotopes



N. Benczer-Koller et al., PLB 664(2008)241

g-factor is very sensitive to relative proton (neutron) composition of nuclear wavefunction !

How to measure magnetic moments ?

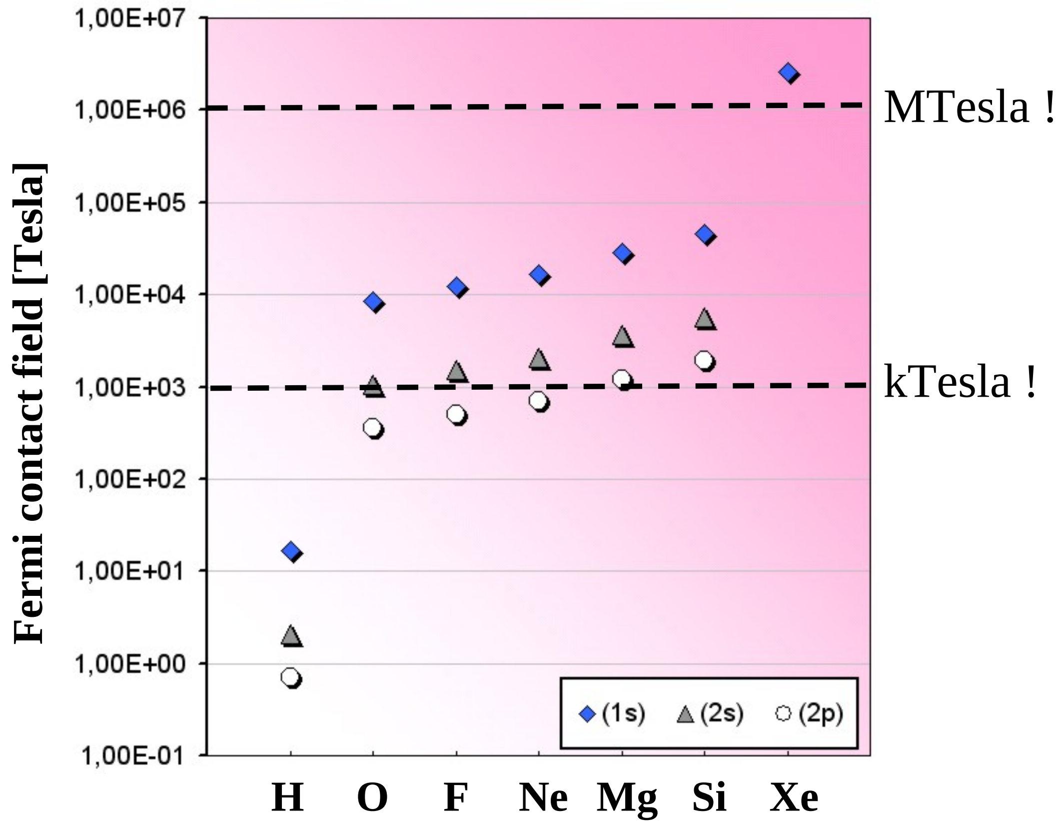
Larmor fre

Time integ
precession

f (<τ) !

Magne ... t the

Fermi con



...orrection factor

randomly oriented electron spins:
<u>attenuation</u> of γ-ray angular correlation
“nuclear deorientation”

oriented electron spins (polarization):
<u>precession</u> of γ-ray angular correlation
“transient fields”

Three different techniques to measure g-factors of short-lived states using radioactive beams

high-velocity transient field

^{38,40}S @ MSU **40 MeV/u**
A.D. Davies et al., PRL 96 (2006) 112503
A.E. Stuchbery et al., PRC 74 (2006) 054307

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^{72}Zn @ GANIL **60 MeV/u**
April 2008   SP: G. Georgiev, A. Jungclaus

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^{42,44,46}Ar @ MSU   &   N=40 Fe @ MSU
October 2008   SP: A.E. Stuchbery

low-velocity transient field

^{132}Te @ Oak Ridge **3.0 MeV/u**
N. Benczer-Koller et al., PLB 664(2008)241

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^{138}Xe @ REX-ISOLDE **2.8 MeV/u**
2006/2009   SP: A. Jungclaus

nuclear deorientation

^{132}Te @ Oak Ridge **3.0 MeV/u**
N.J. Stone, A.E. Stuchbery et al.,
Phys. Rev. Lett. 94 (2005) 192501

Nothing yet at relativistic energies !

Only very few experiments so far ⟹ advantages and disadvantages of the different techniques still need to be explored !

Transient fields: From the low- to the high-velocity regime

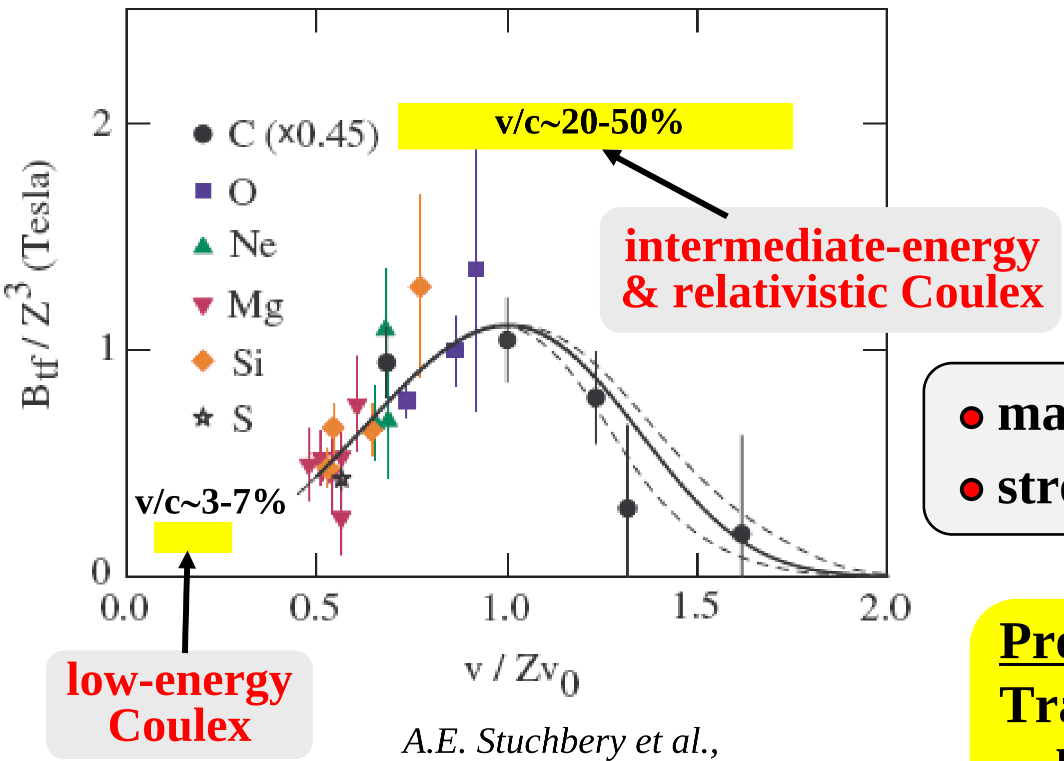
$$B_{tf}(v, Z) = \xi_{1s}(v, Z) \cdot F^{1}_{1s}(v, Z) \cdot B_{1s}(Z)$$

ξ_{1s}: degree of polarization of 1s electrons

F^{1}_{1s}: ion fraction with unpaired 1s electrons

B_{1s}: Fermi contact field of 1s electrons

Transient field strength in Fe host



A.E. Stuchbery et al.,
Phys. Rev. C74 (2006) 054307
Phys. Lett. B611 (2005) 81

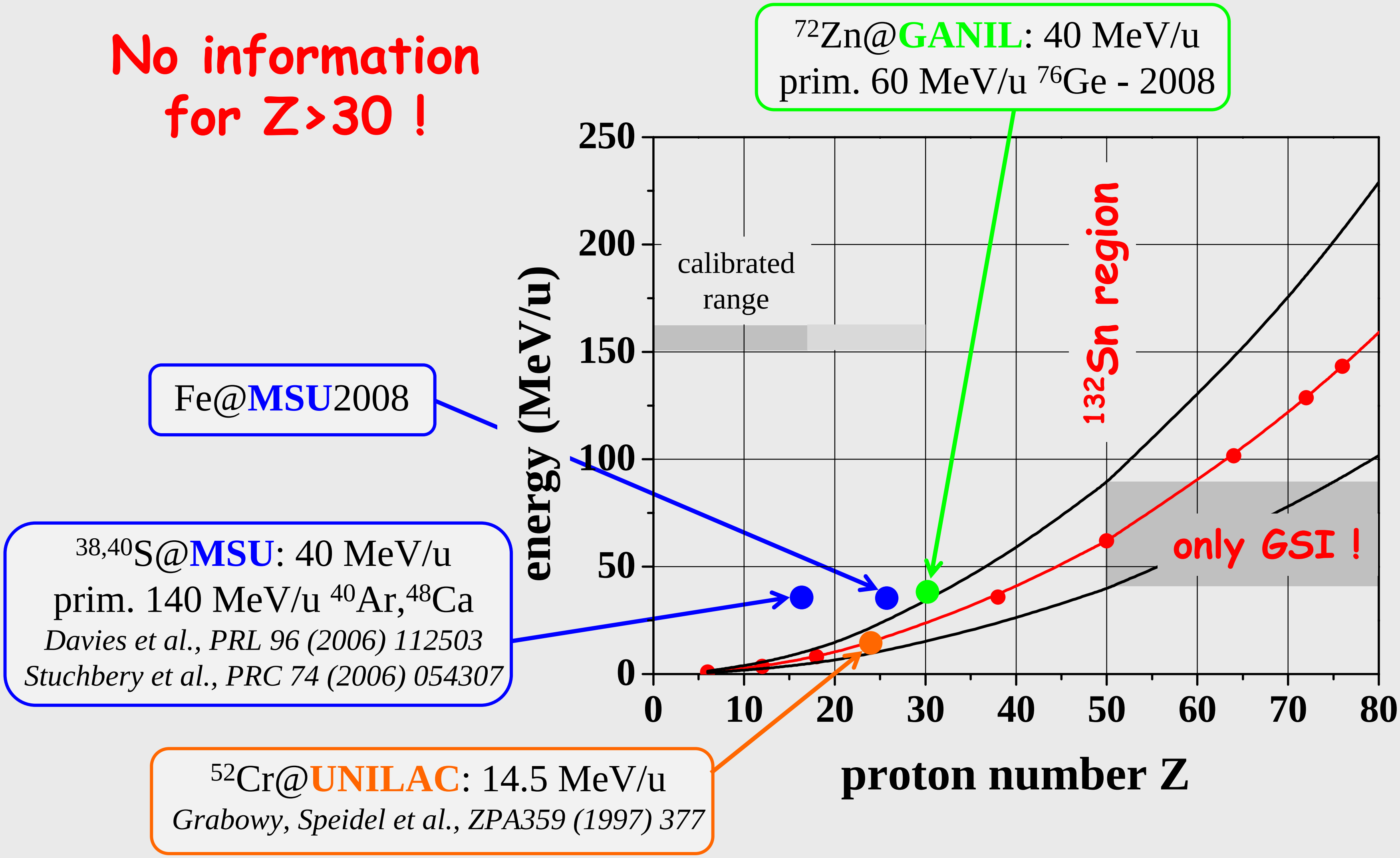
$Z \bullet v_0$: 1s electron velocity

- maximum around $v = Z \bullet v_0$
- strength scales with Z^3 (Z^2 in Gd)

Problem:
Transient field strength studied only up to Sulfur (in Canberra). What happens for higher Z ?

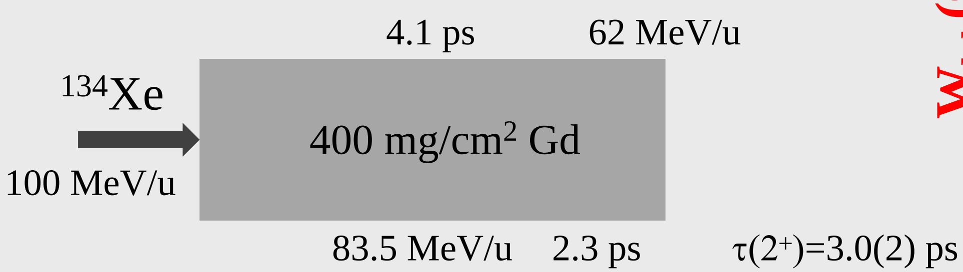
Ion kinetic energy (beam energy) at the 1s electron velocity Zv_0

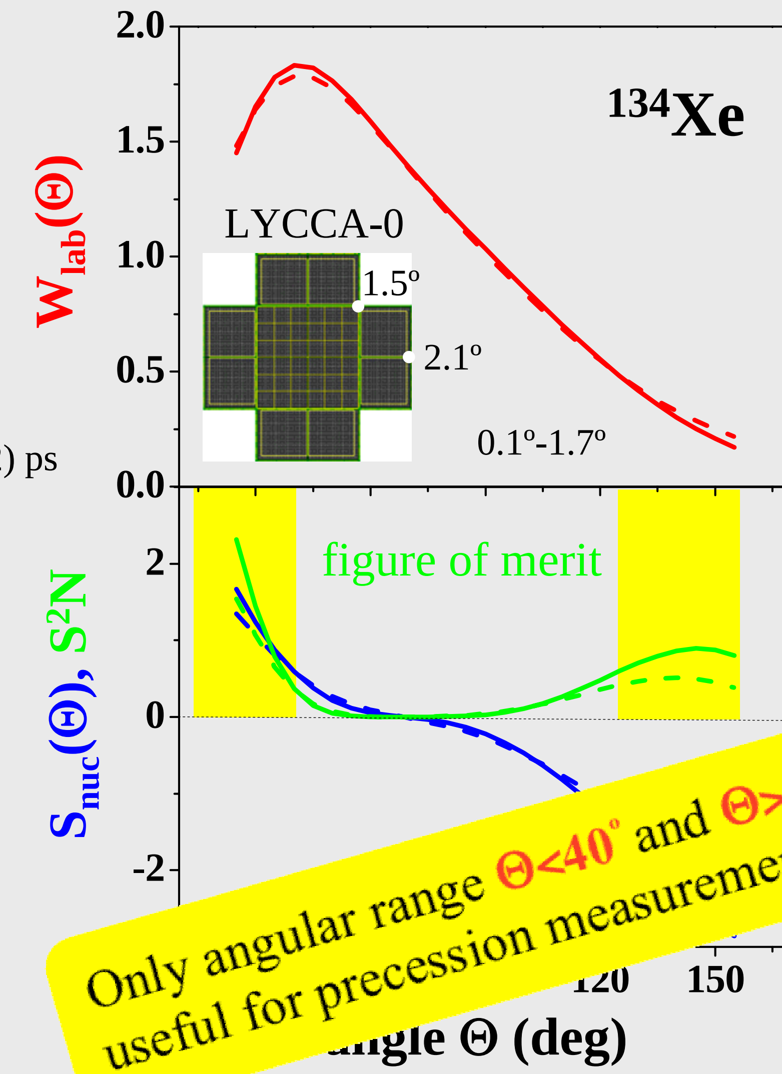
No information for Z>30 !



How to measure the precession of a γ-ray angular correlation with the PRESPEC setup ?

^{136}Xe primary beam @ 500 MeV/u
2.5 g/cm^2 Be target





Only angular range **Θ<40°** and **Θ>120°** useful for precession measurement !

Including decay:

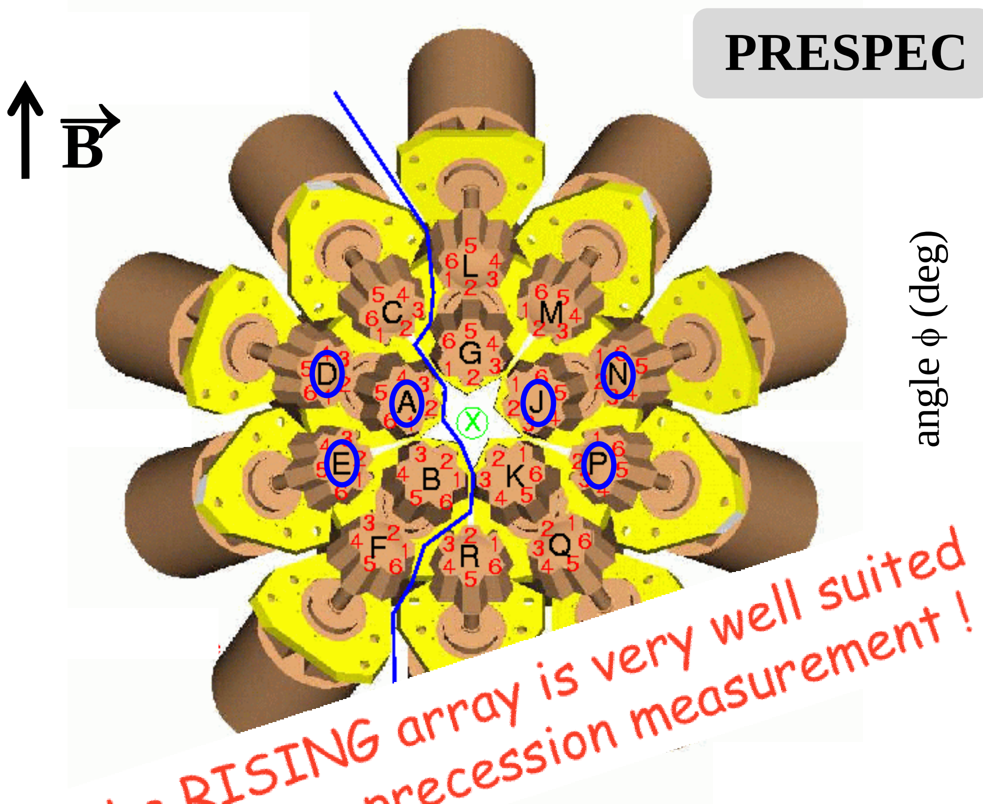
t_{eff} = 1.4 ps, v/Zv_0 = 1.07-0.93

Δφ/g = 129 mrad, B_{ave} = 1.9 kTesla

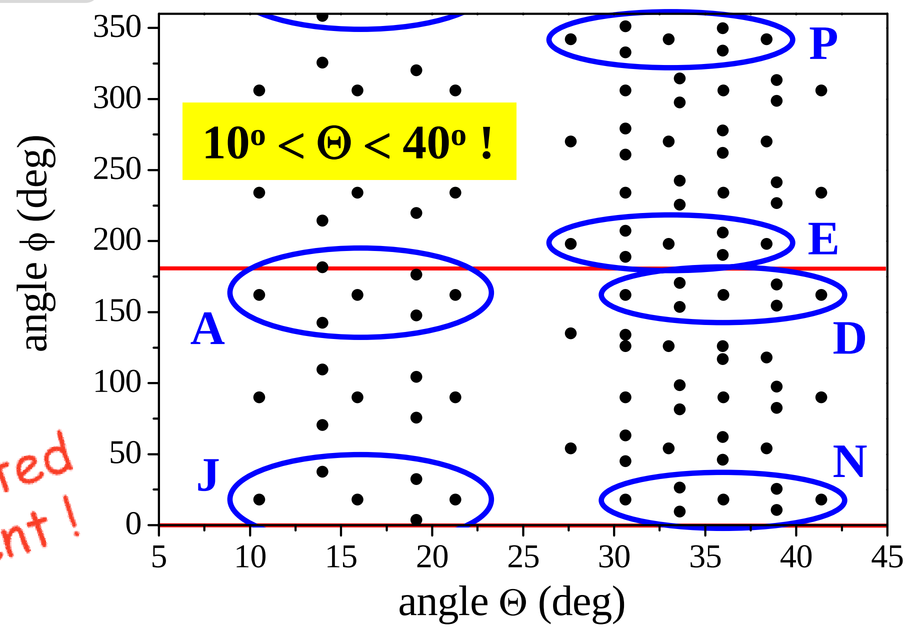
N=7500 photopeak counts per field per day in Clusters A, D and E

Full simulation performed using the code GKINT by A. Stuchbery

Geometry of the PRESPEC Ge array

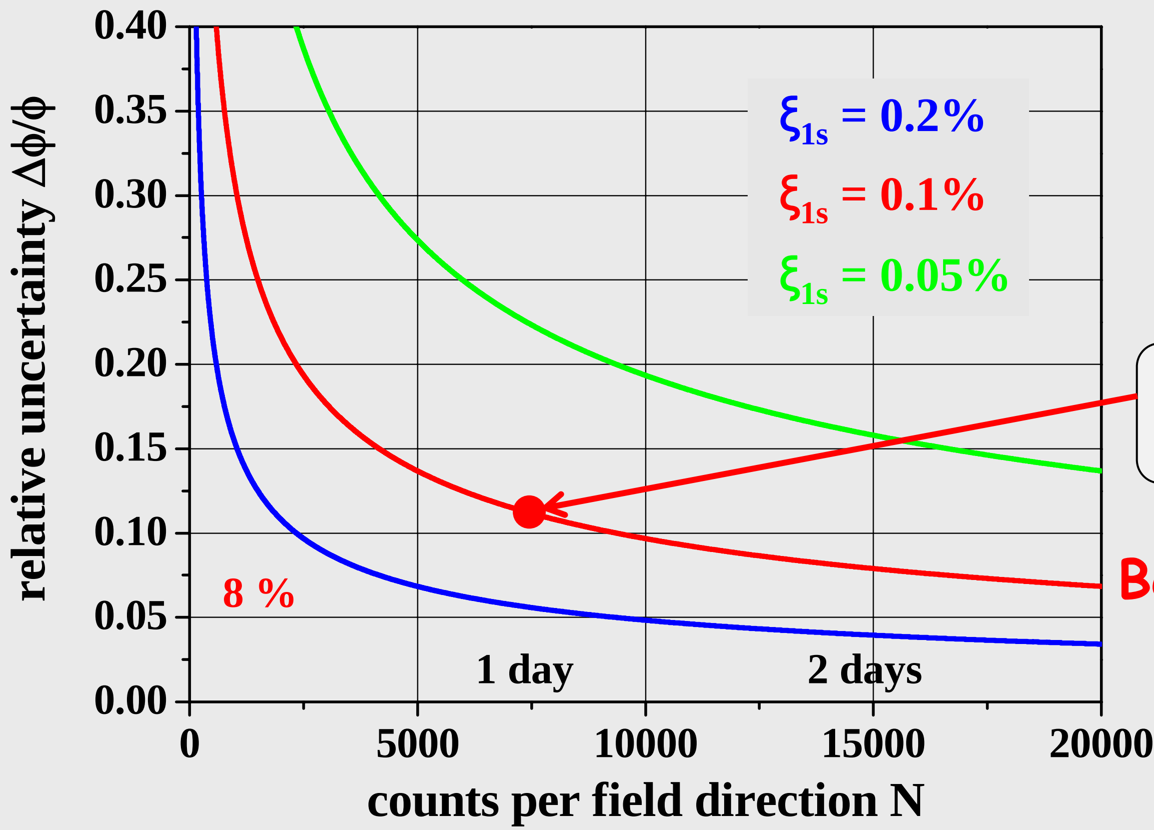


The RISING array is very well suited
for such a precession measurement !



All Ge crystals in the range **Θ<40°** and **three pairs** of Cluster detectors close to the horizontal plane !

Relative uncertainty of the TF strength as a function of statistics/time



Large uncertainties in this estimate due to:

- unknown field strength
- unclear rate limitations

30 shifts of parasitic beam approved in 2009 !

Best guess !

It is most important to see **an effect** for the first time !

Then we can do proper estimates for real g(2$^+$) measurements …

RISING fast-beam proposal in 2002

Magnetic moments of Xenon and Tellurium isotopes near doubly-magic ^{132}Sn at relativistic beam energies.

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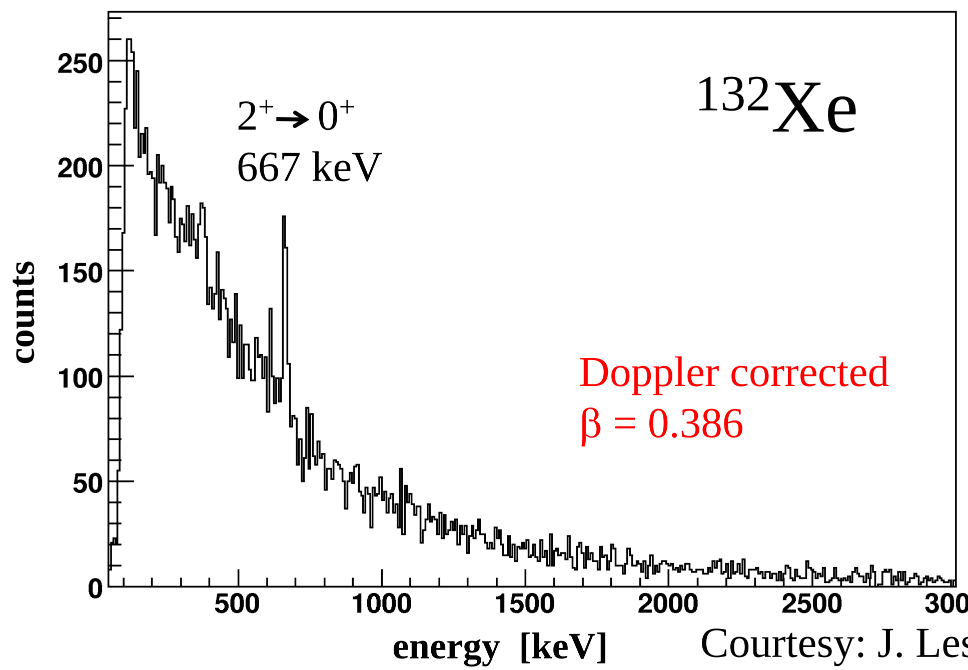
S. K. Mandal, H.-J. Wollersheim for the RISING collaboration
Gesellschaft für Schwerionenforschung, D-64220 Darmstadt, Germany



Courtesy: J. Leske

proposed and approved in 2002
comissioning run scheduled in 2005

Block 1 / 2005										March 2005							
Week 9						Week 10							Week 11				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
EC R 54 Cr	U211, Sulignano, 54Cr (ECR), 4.5-5.3 MeV/u, 1 pmicroA, Y7													U000, machine experiments			
	a)							b)			UMAT, Trautmann, 152Sm (PIG), 11.4 MeV/u, X0						
	M001,Scheeler (PIG), various energies, low duty cycle, Z																
S269-9, Speidel/Mandal, 132Xe (MUCIS), 200, 500, 900 MeV/u, 1e6/spill, 4s extr constant spill, FRS-S4							S285, Saito, 152Sm (PIG), 750 MeV/u, 1e8/spill, 4s extr constant spill, FRS-S4							S000, machine experiments			
E056, Dubois/Stoehlker, 132Xe18+ (MUCIS), 50 MeV/u, jet target, ESR-H2									c)								
							M001, Scheeler, 152Sm (PIG), various energies, low duty cycle, HTP										

Stopped in 2005 after only a few hours !

Summary & Conclusions

Magnetic moment information is important (sometime $E(2^+)$ and $B(E2)$ is not sufficient) !

TF strength only known up to Z=16 (30)

We need at least one calibration point to tackle the **^{132}Sn region.**

Approved parasitic beamtime at GSI !

Transient fields (TF) largest around 1s electron velocity

Relativistic heavy ions "in principle" well suited for $g(2^+)$ measurements !

GSI only !

Once the TF strength is known real **physics cases in the ^{132}Sn region** can be studied with the AGATA@GSI setup !

LYCCA performance in A~130 region !