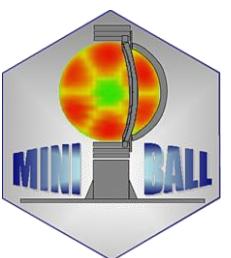


Coulomb excitation of neutron-rich $^{32,33}\text{Mg}$ nuclei with MINIBALL at HIE-ISOLDE

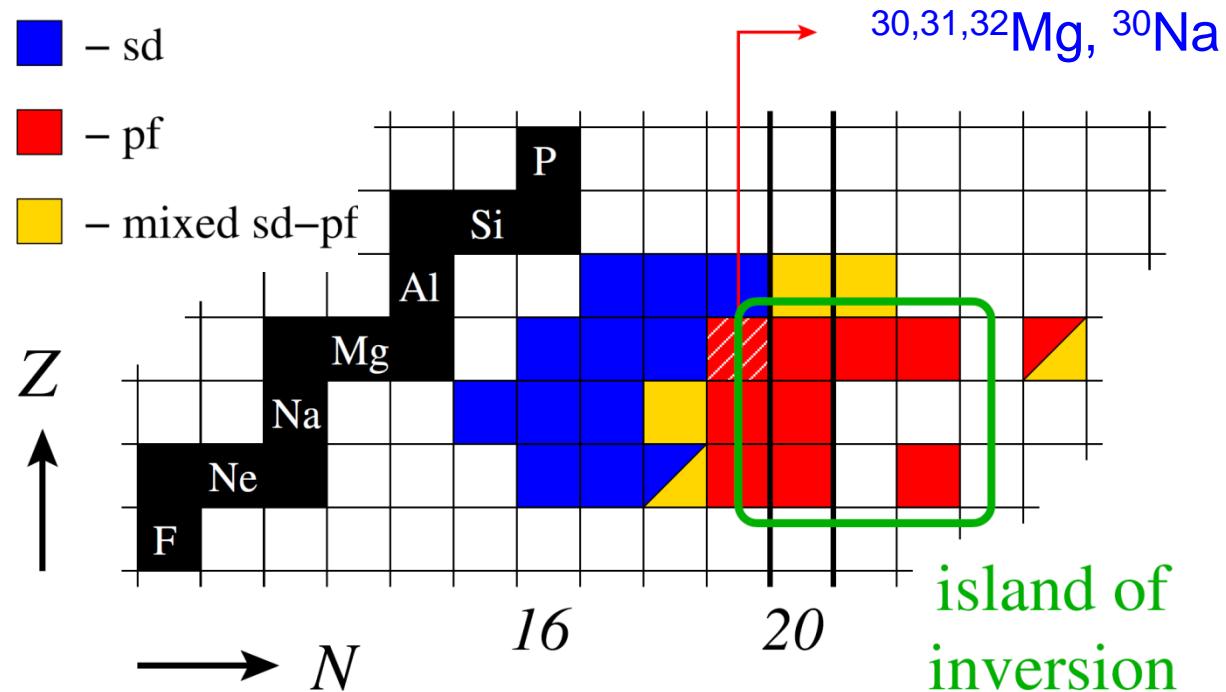
P. Reiter¹, B. Siebeck¹, M. Seidlitz¹, A. Blazhev¹, K. Geibel¹, N. Warr¹, A. Wendt¹, P. Van Duppen²,
K. Wrzosek-Lipska², N. Kesteloot², M. Huyse², E. Rapisarda³, T. Stora³, D. Voulot³, F. Wenander³,
Th. Kröll⁴, N. Pietralla⁴, M. Scheck⁴, R. Gernhäuser⁵, R. Krücken^{5,6}, D. Mücher⁵, J. Cederkäll⁷,
C. Fahlander⁷, D. Jenkins⁸, P. Butler⁹, L. Gaffney⁹, G. O'Neill⁹, T. Davinson¹⁰,
P.J. Woods¹⁰, T. Grahn¹¹, P.T. Greenlees¹¹, P. Rahkila¹¹, J. Pakarinen¹¹
and the MINIBALL and HIE-ISOLDE collaborations

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⁷ University Lund, Sweden, ⁸ University York, United Kingdom,
⁹ University Liverpool, United Kingdom, ¹⁰ University Edinburgh, United Kingdom,
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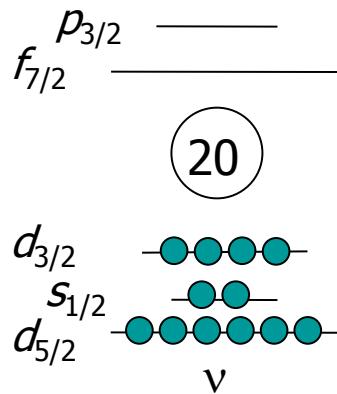
Spokesperson: Peter Reiter (preiter@ikp.uni-koeln.de)
Local contact: Elisa Rapisarda (Elisa.Rapisarda@cern.ch)



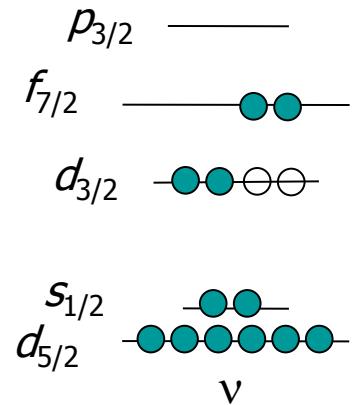
physics motivation - proposed experiment - feasibility and rates



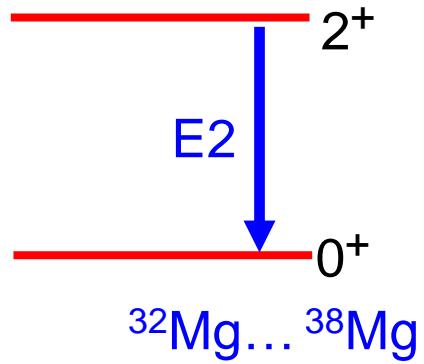
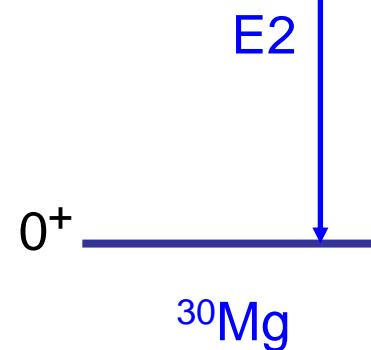
$0p0h$, spherical



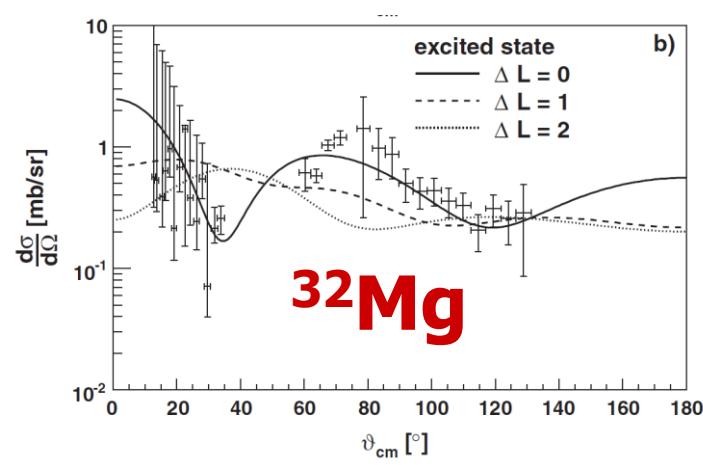
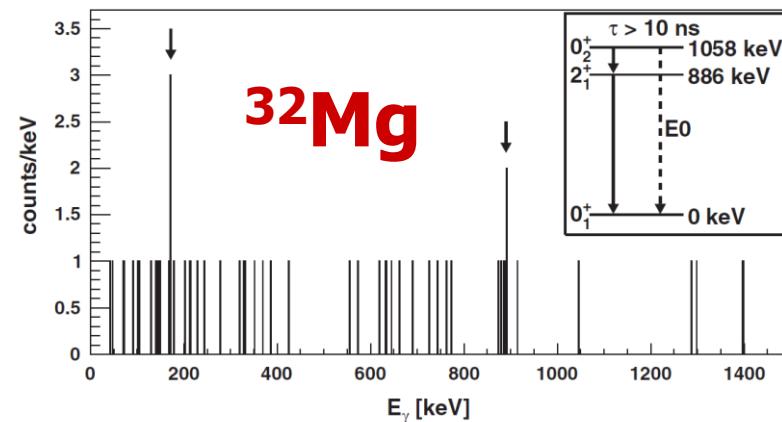
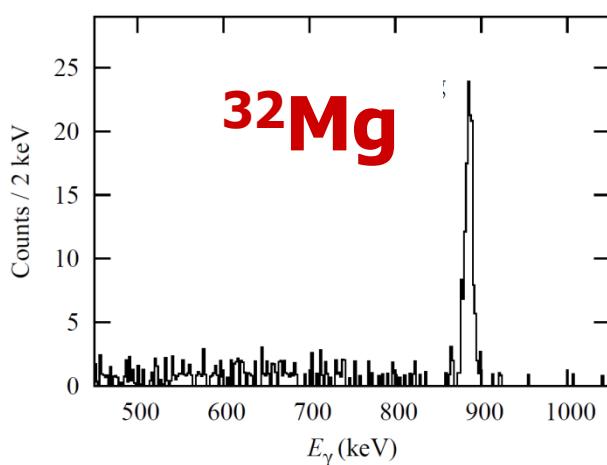
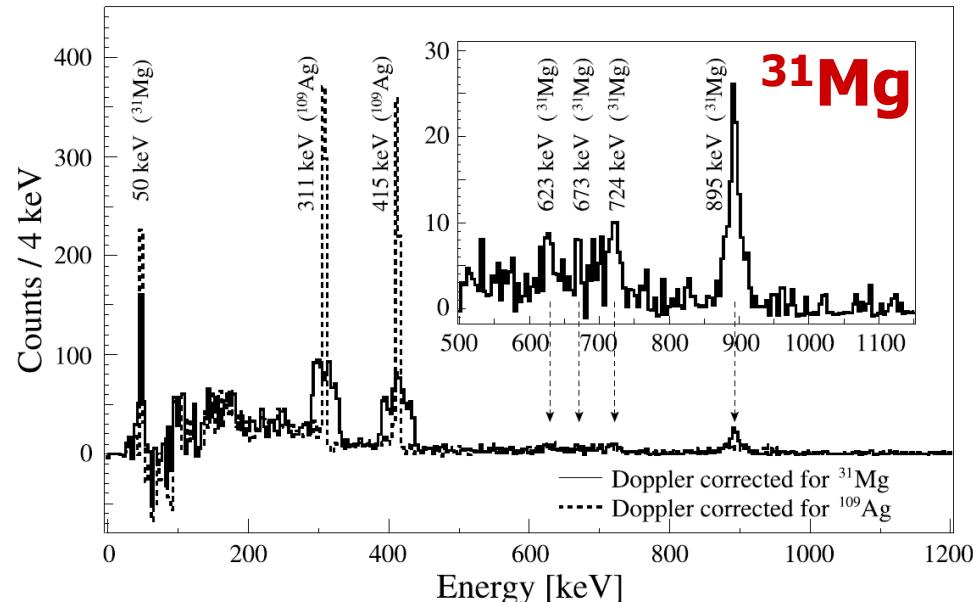
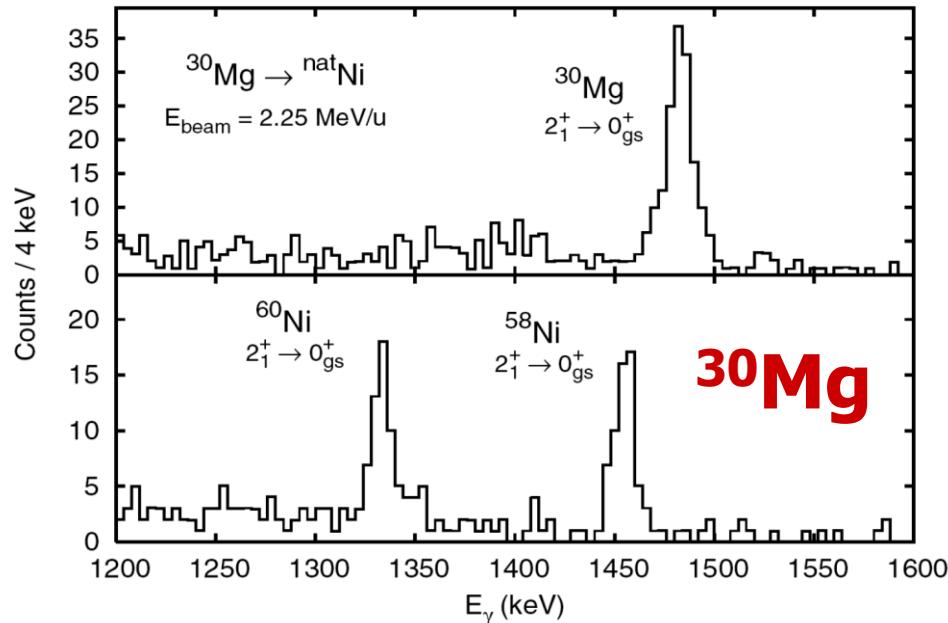
$2p2h$ (intruder), deformed



2^+



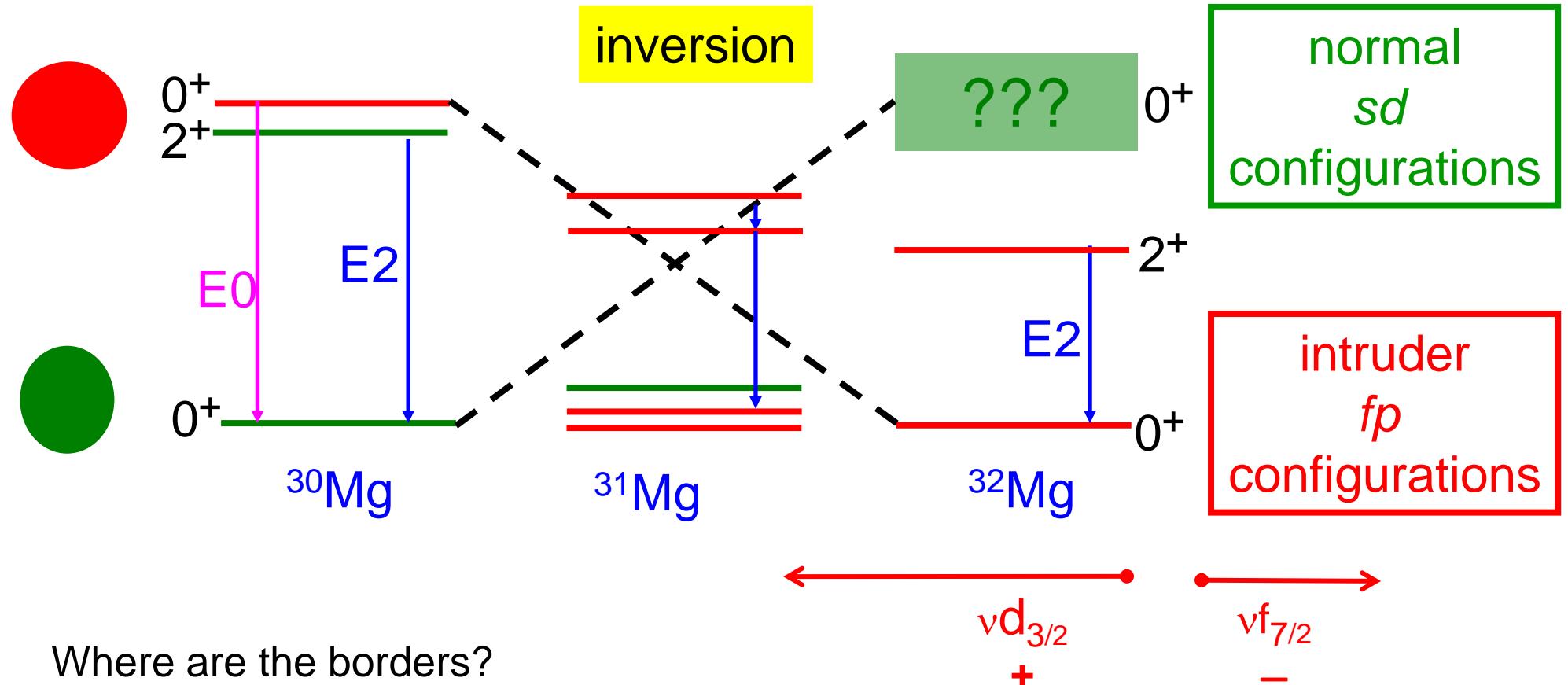
„Island of Inversion“ MINIBALL results



O. Niedermeier, *et al.*,
 Phys. Rev. Lett. **94**, 172501 (2005)

M. Seidlitz *et al.*,
 Phys. Lett. B 700 (2011) 181

K. Wimmer *et al.*,
 Phys. Rev. Lett. **105**, 252501 (2010)



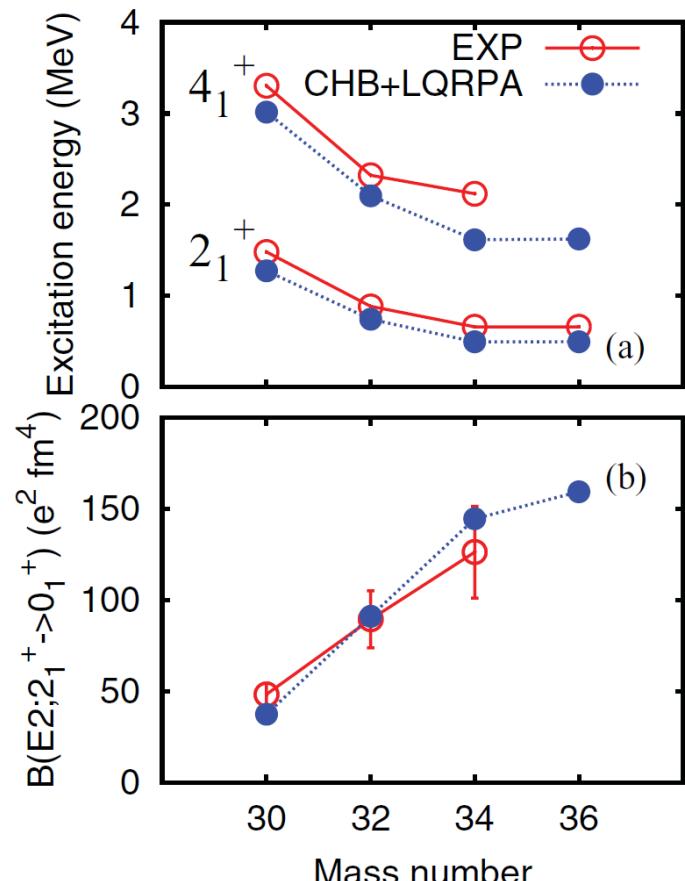
Where are the borders?

How does transition into island of inversion occur ?

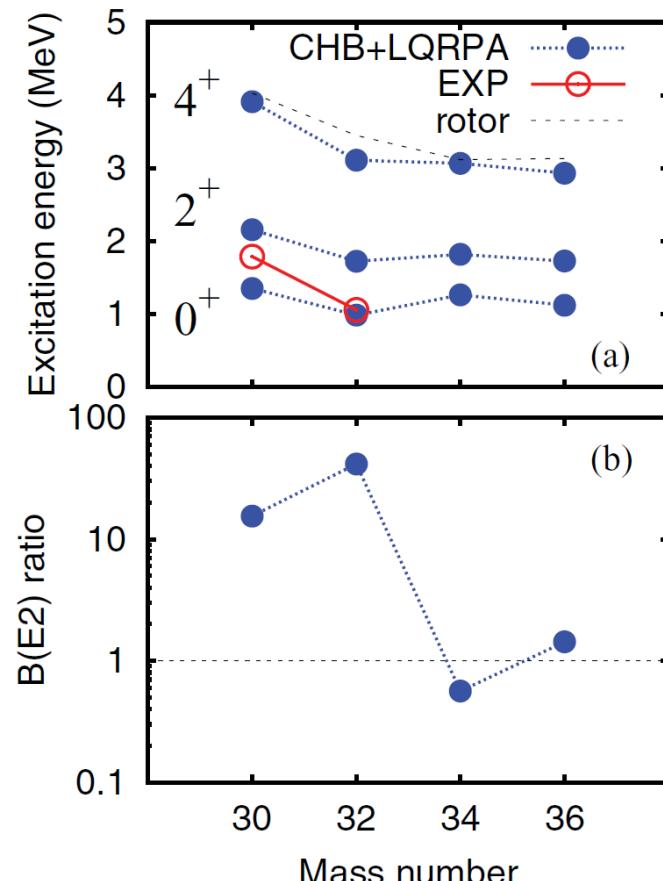
Does picture of shape coexistence hold?

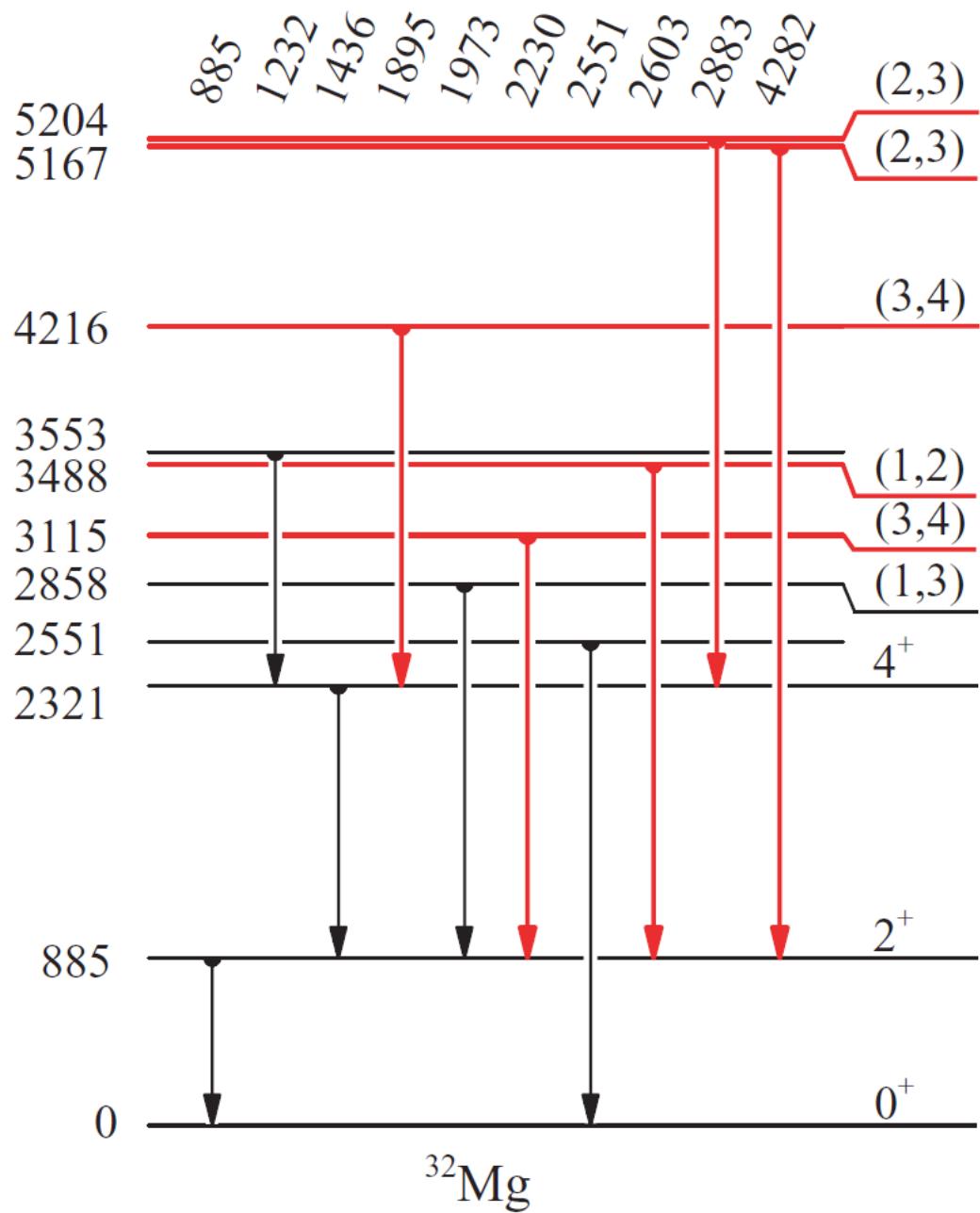
30,32,34,36Mg theory results

collectivity of 4_1^+ and 3_1^- states
 theory: $B(E2; 4_1^+ \rightarrow 2_1^+)$, $B(E2; 2_1^+ \rightarrow 3_1^-)$
 size of the $d_{3/2}$ - $f_{7/2}$ shell gap



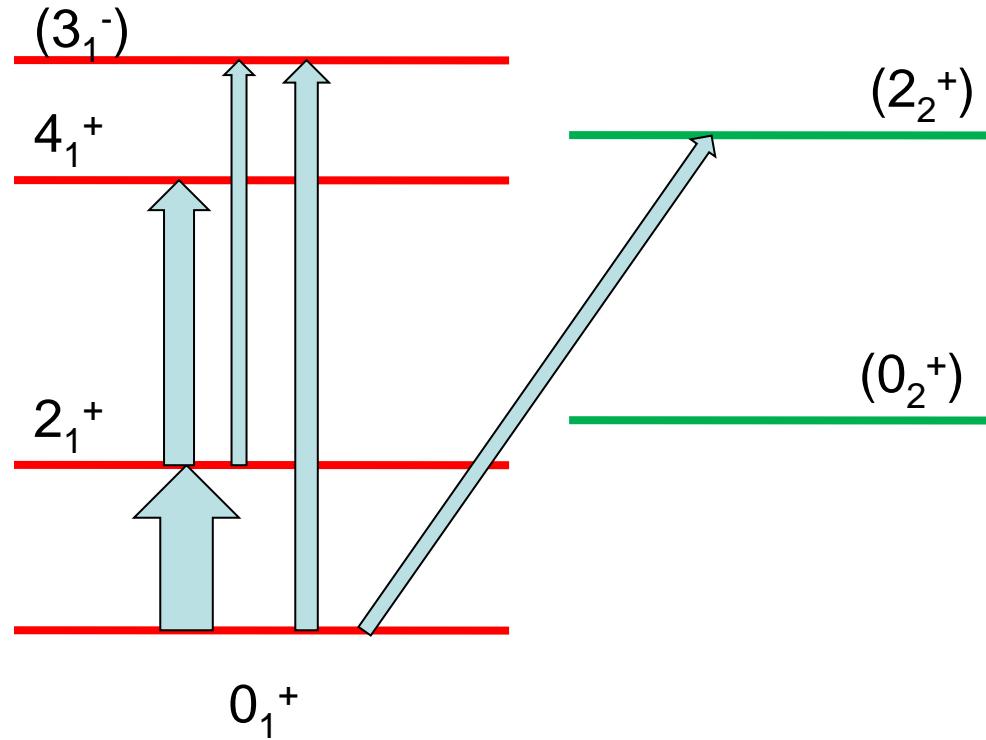
predictions for $B(E2; 0_1^+ \rightarrow 2_2^+)$

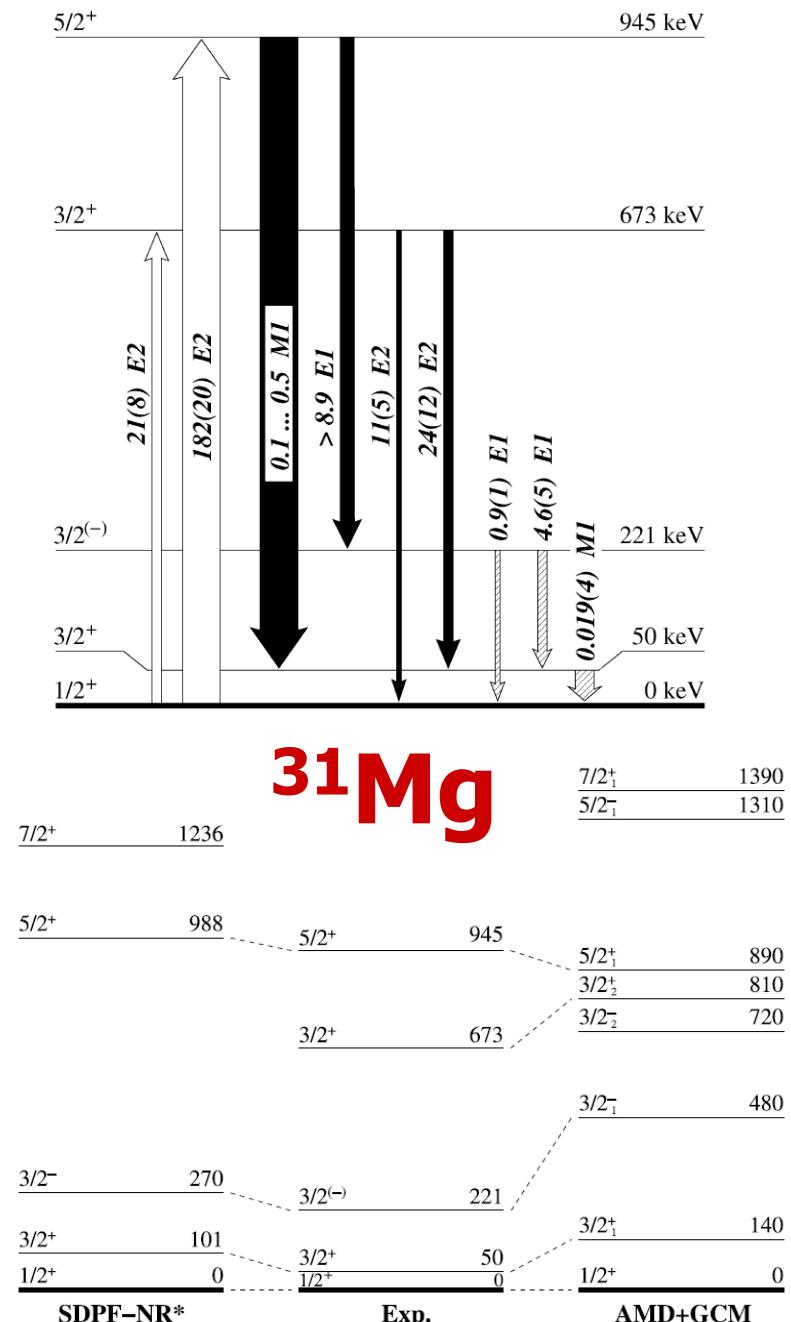




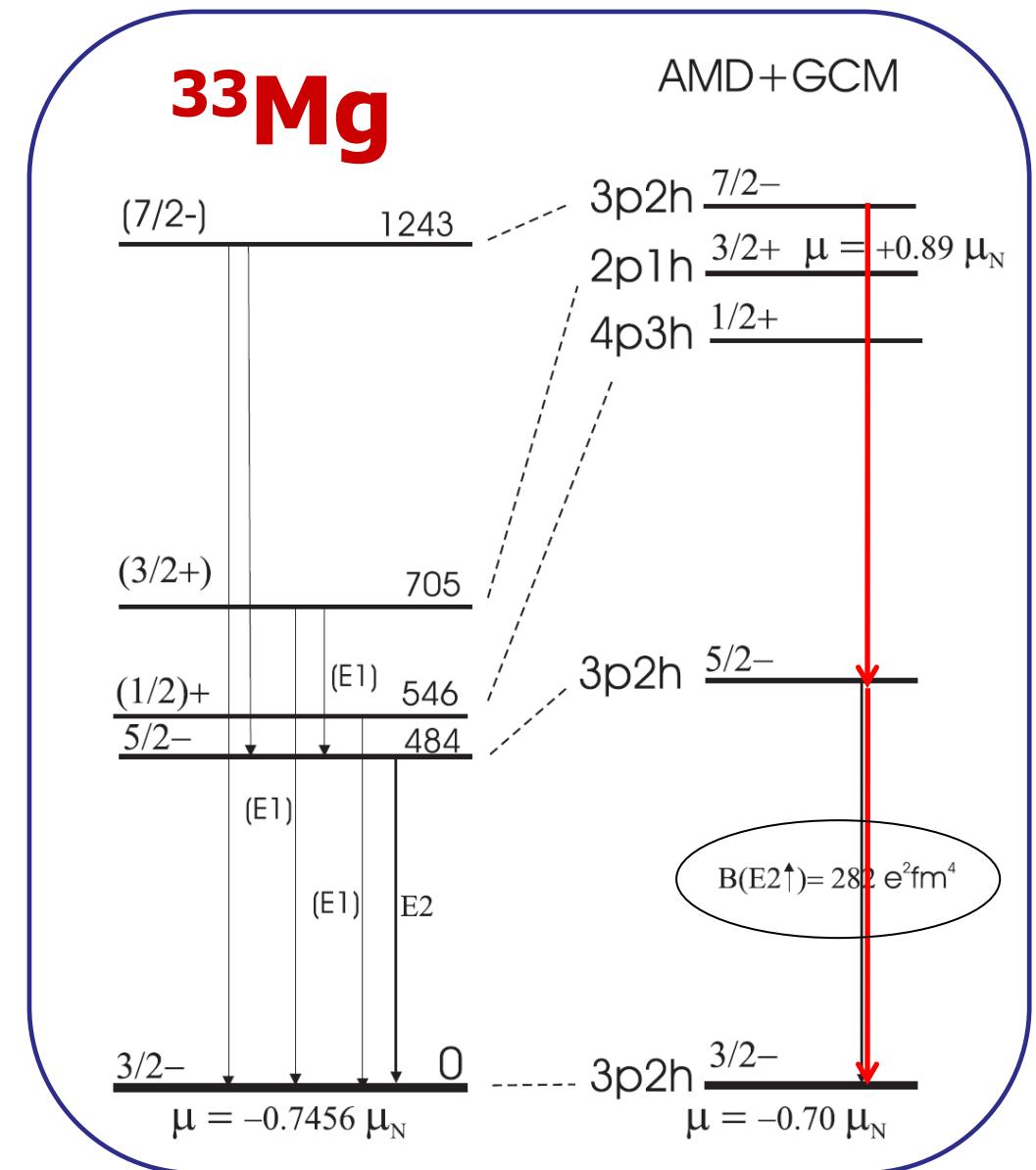
Intermediate Coulomb excitation is limited to single step excitation

Safe Coulex at higher beam energy will allow for multiple Coulex





M. Seidlitz *et al.*; Phys. Lett. B 700 (2011) 181



$B(E2, 3/2^-_1 \rightarrow 5/2^-_1), B(E2, 5/2^-_1 \rightarrow 7/2^-_1) ?$
 G. Neyens, Phys. Rev.C84, 064310 (2011).
 M. Kimura, arXiv:1105.3281v1.

ISOLDE beam intensities

element	A	half life	Accelerator	Ions/ μ C	target material
Mg	32	120 ms	PSB	3.0E+04	UC _x
Mg	33	90 ms	PSB	3.0E+03	UC _x
Mg	34	20 ms	PSB	1.4E+02	UC _x

Previous ISOLDE beams

^{31}Mg (1.5×10^4 ions/s)

G. Neyens et al.; PRL 94, 022501 (2005) Spin and Magnetic Moment of ^{31}Mg

^{32}Mg (5×10^4 ions/s)

D. T. Yordanov et al.; PRL 108, 042504 (2012) Nuclear Charge Radii of $^{21-32}\text{Mg}$

^{33}Mg (2.5×10^3 ions/ μ C)

D. T. Yordanov et al.; PRL 99, 212501 (2007) Spin and Magnetic Moment of ^{33}Mg

REX-ISOLDE delivered $^{30}\text{Mg}^{7+}$ and $^{32}\text{Mg}^{9+}$ beams on the secondary MINIBALL target with intensities of 10^5 s^{-1} and 10^4 s^{-1} .

Accelerator efficiency for the complete REX-ISOLDE chain for $^{30,31,32}\text{Mg}$ beams was 6%-10%.

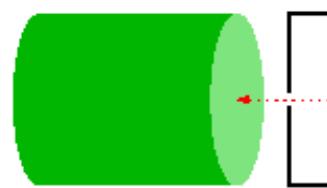
Count rate estimate is based on

- ^{32}Mg (2×10^4 ions/s) and ^{33}Mg (2×10^3 ions/s) at MINIBALL target

- HIE-ISOLDE accelerator efficiency for $^{32,33}\text{Mg}$ beams assumed to be 5%

Experiment - setup

Bragg chamber



beam
composition

TU München

Particle detection

Scat. Angle: $\Delta\theta_{\text{Lab}} = 15^\circ - 77^\circ$
 $\Delta\theta_{\text{CM}} = 25^\circ - 115^\circ$

γ -spectroscopy

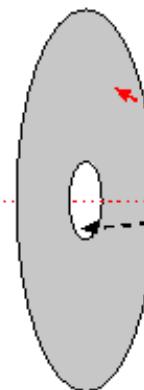
Efficiency @ 1 MeV $\sim 9\%$

PPAC
(optional)



MINIBALL + TREX

DSSSD

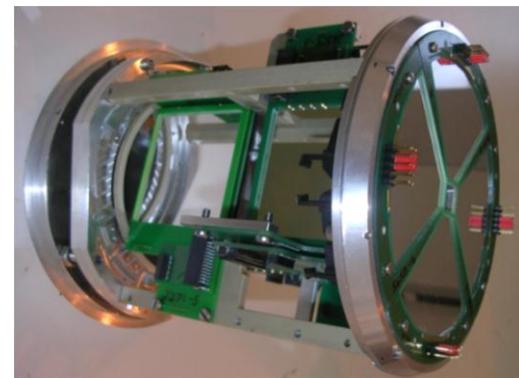
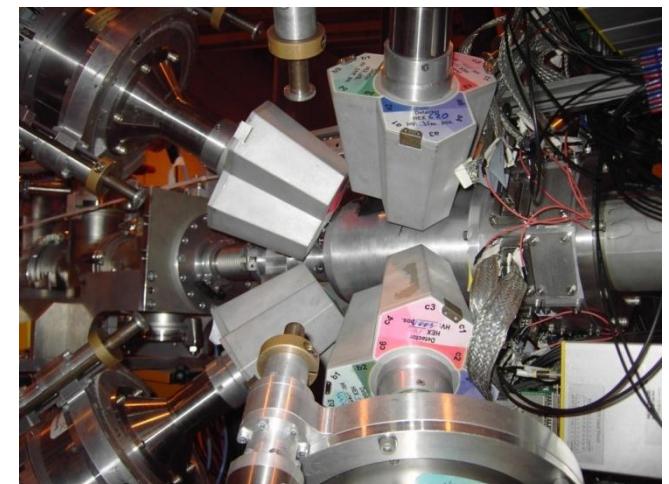


θ_y
 ^{196}Pb target
7.5 mg/cm²

$^{32,33}\text{Mg}$ beam

Ebeam ~ 5.5 MeV/u

γ -spectroscopy



TU München, K.U. Leuven

Uni Köln, K.U. Leuven

Count rate estimate & beam time request

	primary ISOLDE yield (ions/ μ C)	beam intensity at MINIBALL (ions/s)	transition/ energy (keV)	B(E2) \uparrow values $e^2 fm^{2L}$ *theory **assumed	integrated Coulex x-section (mbarn)	Events in the photo peak count rate in hours		shifts
						Cts/h	Cts/ 120h	
^{32}Mg	3×10^5	2×10^4	$2_1^+ \rightarrow 0_1^+$ 885 keV	454	1110	150	18000	15
^{32}Mg	3×10^5	2×10^4	$4_1^+ \rightarrow 2_1^+$ 1436keV	288*	500	5	600	
^{32}Mg	3×10^5	2×10^4	$3_1^- \rightarrow 2_1^+$ 1973keV	2500**	10	1	120	
^{32}Mg	3×10^5	2×10^4	$0_1^+ \rightarrow 2_2^+$ 2550keV	45**	40	2.5	300	
^{33}Mg	3×10^4	2×10^3	$5/2_1^- \rightarrow 3/2_1^-$ 485keV	282*	795	16	1920	15
^{33}Mg	3×10^4	2×10^3	$7/2_1^- \rightarrow 3/2_1^-$ 1243 keV	154*	350	2	240	
			$7/2_1^- \rightarrow 5/2_1^-$ 758keV	147*		2.5	300	

Summary

The proposal aims for considerable advances in two decisive nuclei $^{32,33}\text{Mg}$ of the island of inversion.

- quest for nature of higher lying transitions in ^{32}Mg
- size of the $d_{3/2}$ - $f_{7/2}$ shell gap
- theory: $B(E2; 2_1^+ \rightarrow 4_2^+)$, $B(E2; 2_1^+ \rightarrow 3_1^-)$, $B(E2; 0_1^+ \rightarrow 2_2^+)$
- predictions for $B(E2, 3/2_- \rightarrow 5/2_-)$, $B(E2, 5/2_- \rightarrow 7/2_-)$ values for ^{33}Mg

Main advantages of the HIE-ISOLDE-MINIBALL experiment

- (i) high beam energy of the HIE-ISOLDE
 - two-step Coulex with high Z target, higher cross sections
- (ii) high energy resolution and high efficiency of the MINIBALL HPGe detectors, low detection threshold ~50 keV

Requested shifts: 5 days (15 shifts) for ^{32}Mg experiment
5 days (15 shifts) for ^{33}Mg experiment