2^+ Anomaly and Configurational Isospin Polarization of ^{136}Te

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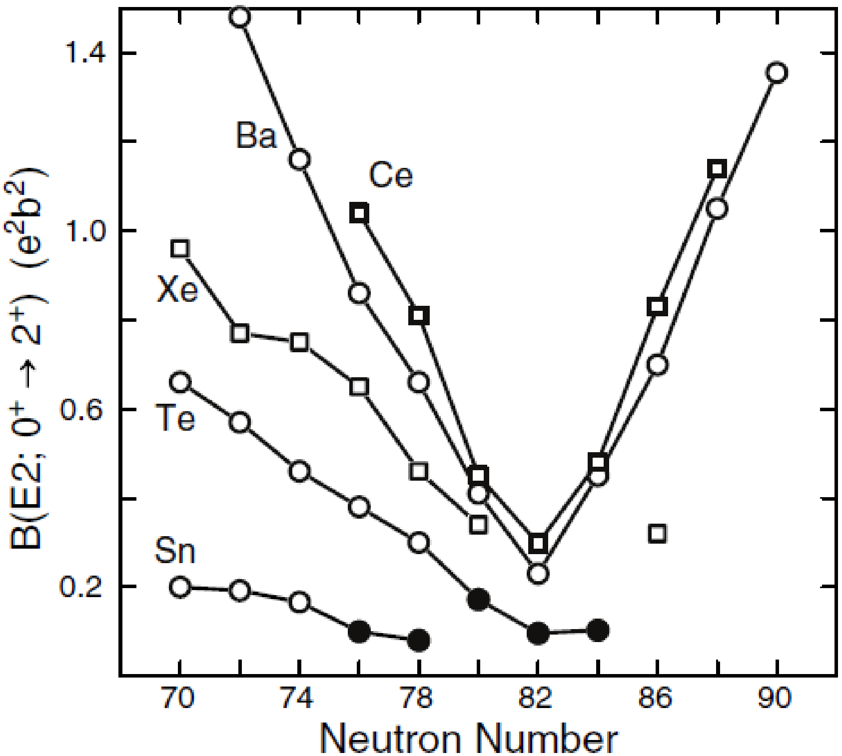
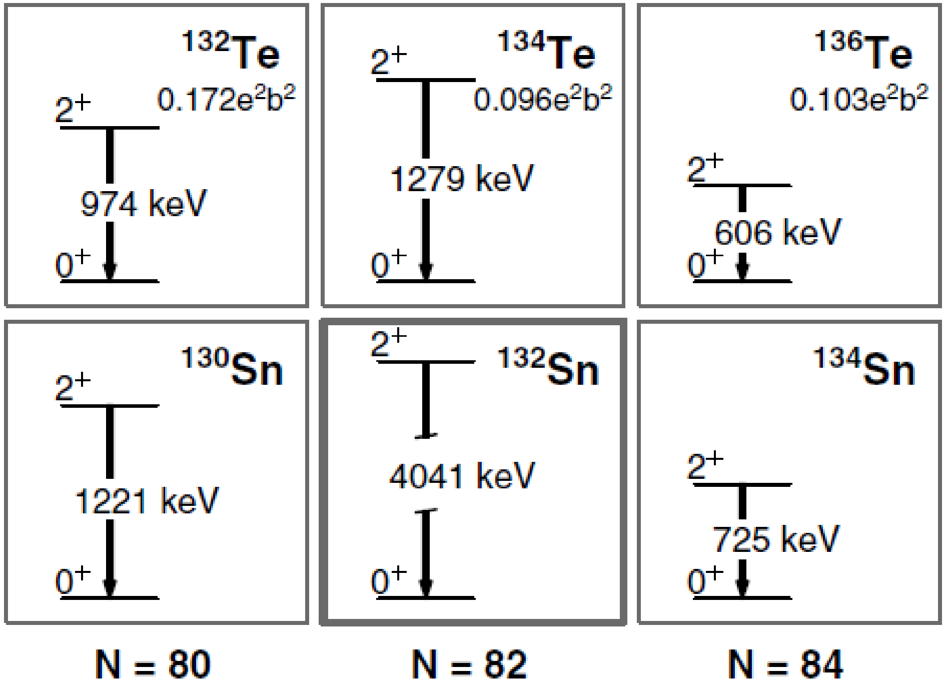
The „Anomaly“ of 136Te

Unbalanced p and n contributions of the wavefunction of the states

D. C. Radford et al., PRL 88, 222501 (2002)





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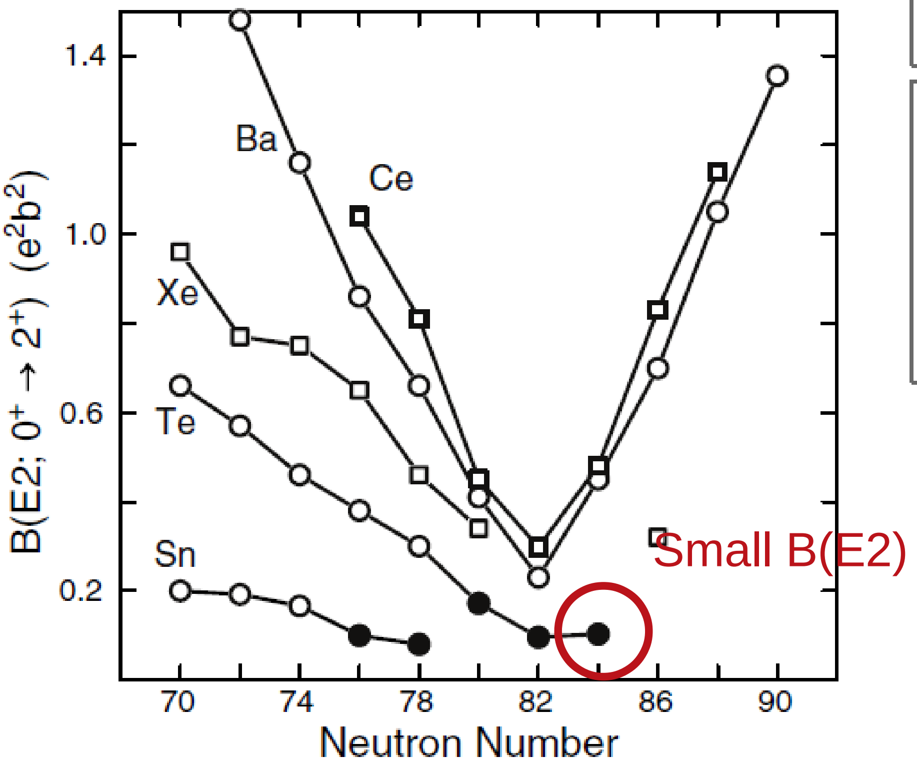

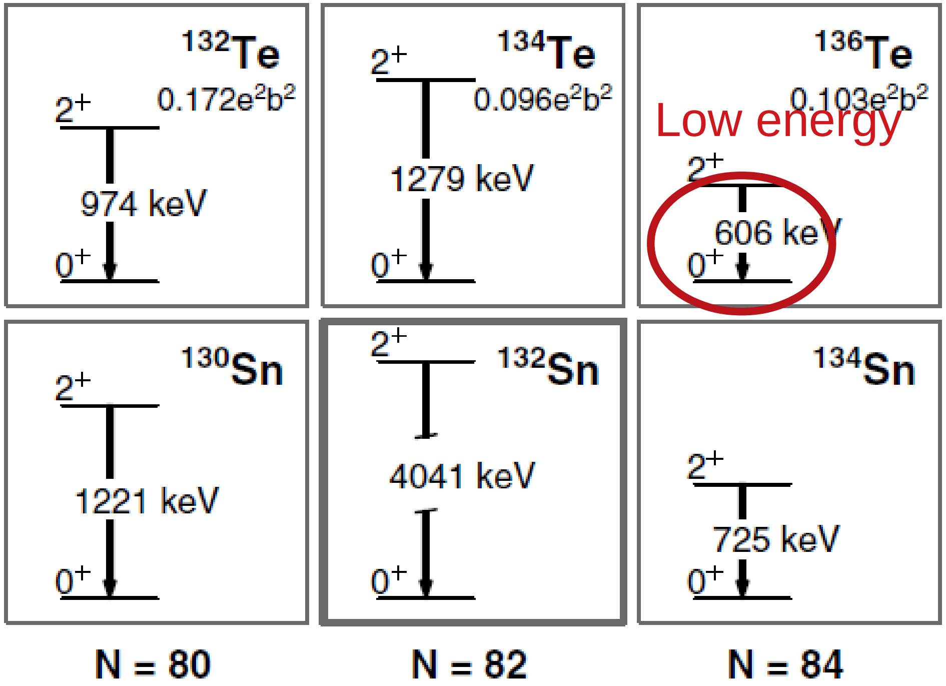

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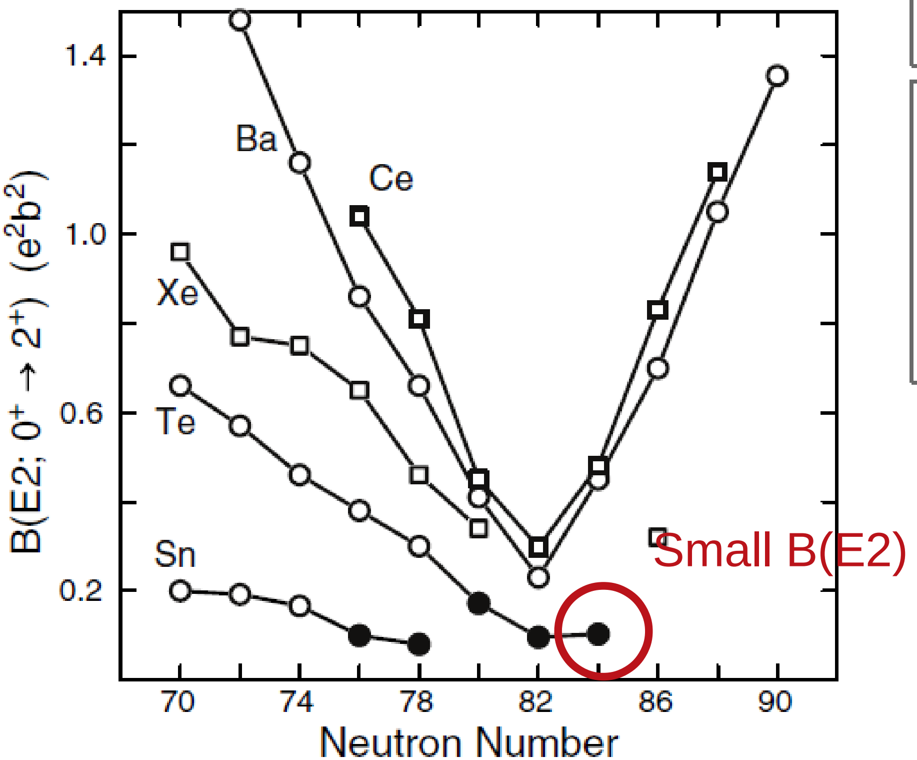
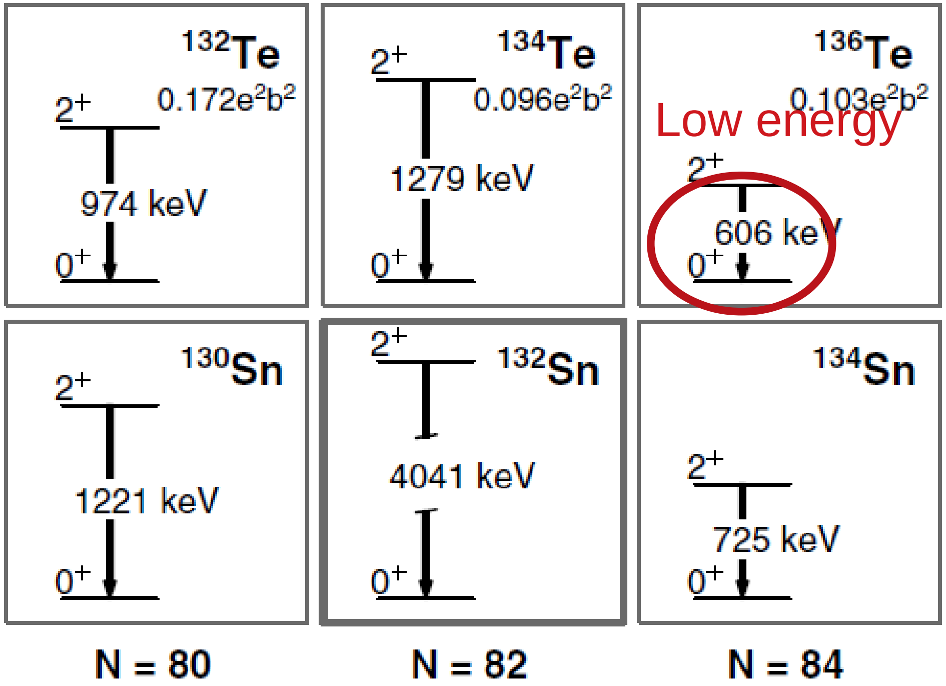




Shell model:
N. Shimizu, T. Otsuka, T. Mizusaki, M. Honma, PRC 70, 054313 (2004)
QRPA:
J. Terasaki et al., PRC 66, 054313 (2002)

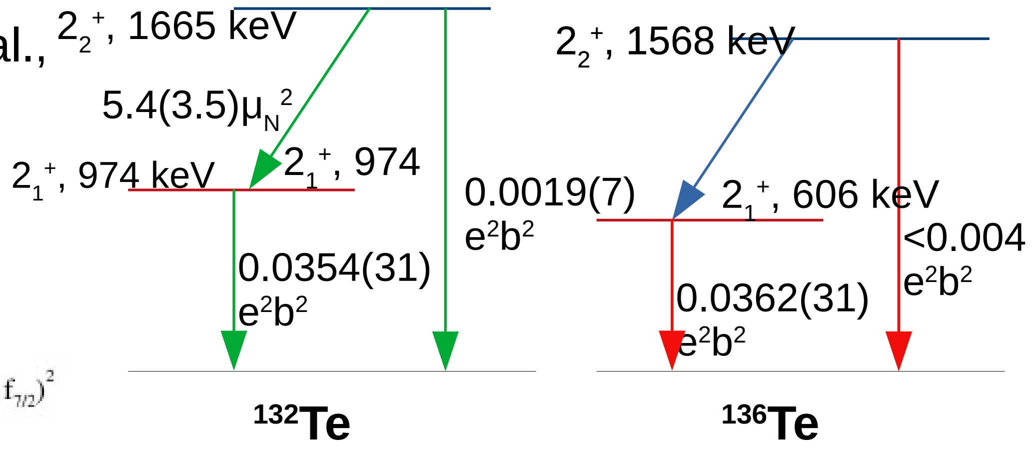
Physics case
Configurational Isospin Polarization (CIP)

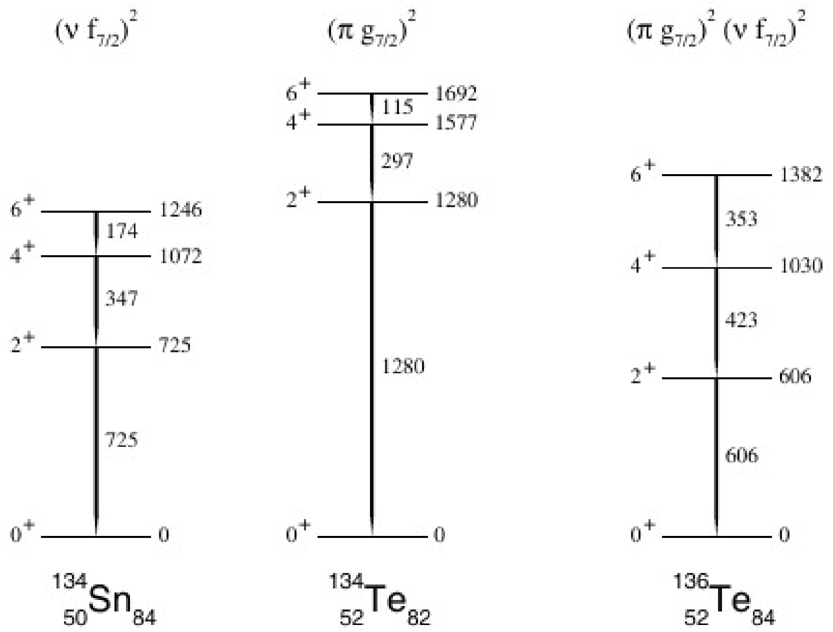
CIP observed in ^{92,94}Zr (V. Werner et al., PRC 78, 031301(R) (2008))

→ weak p-n interaction

2_1^+ - neutron dominated WF

2_2^+ - proton dominated WF





M. Danchev et al., PRC 84, 061306 (2011)
V. Vaquero et al., PRC 99, 034306 (2019)
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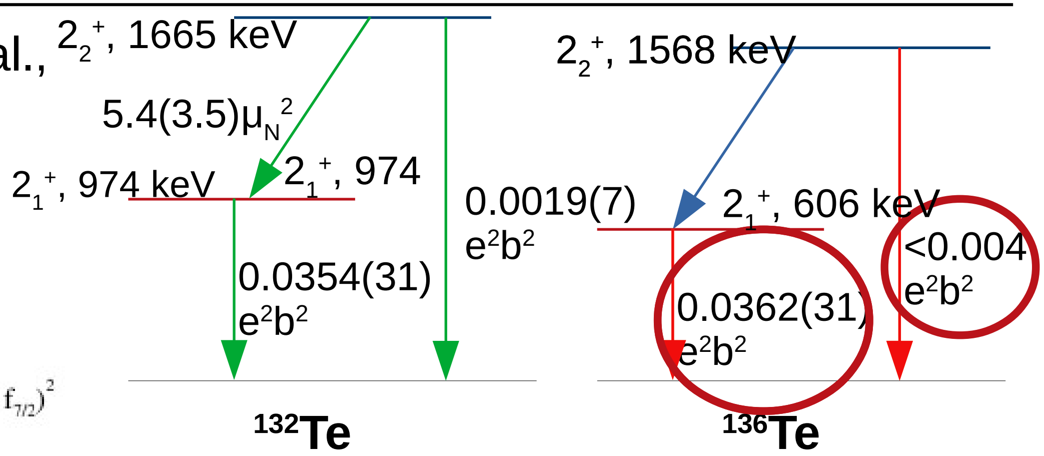

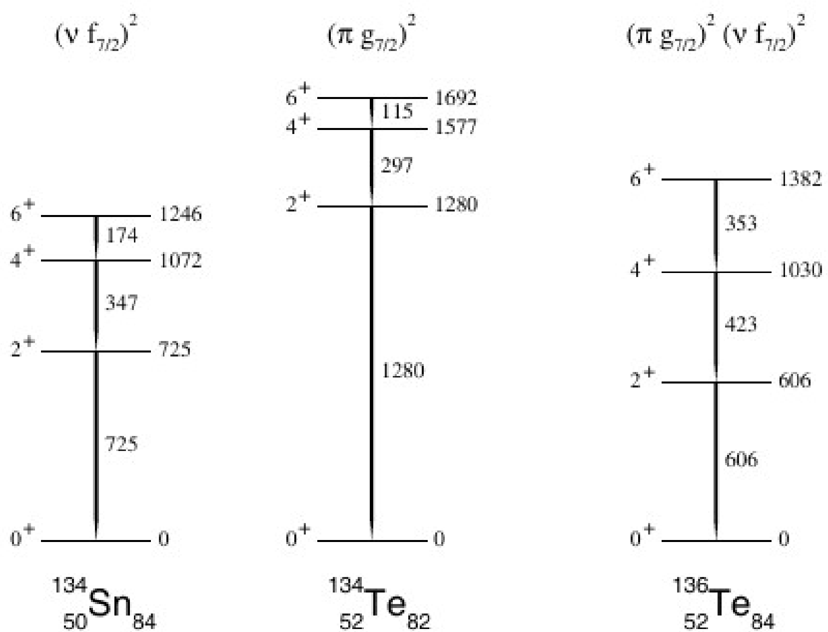

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Key Observables for the one-phonon mixed-symmetry 2+ state of ^{132}Te

***R. Zidarova, V. Werner**, N. Pietralla*

Submitted Proposal to IFIN, Bucharest

New Physics Case

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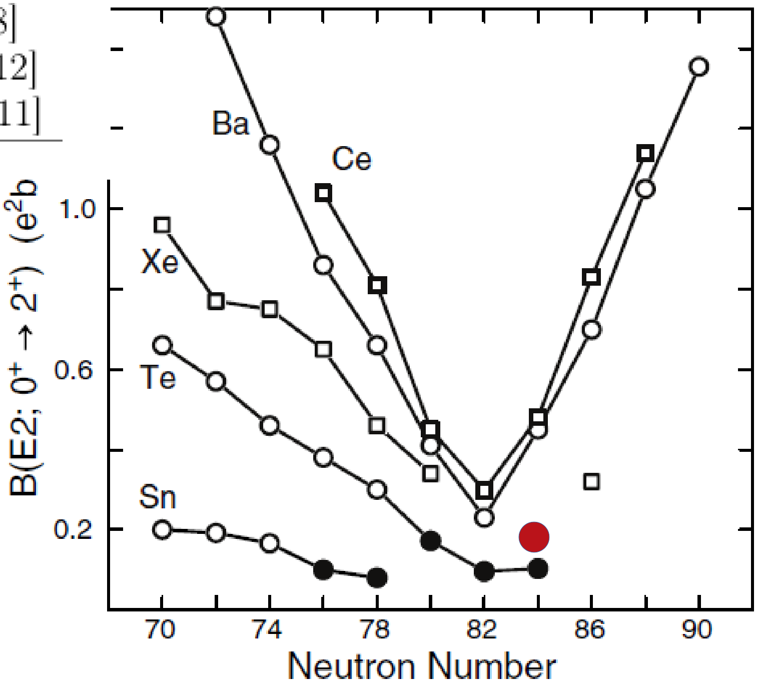
Recent work rules out CIP in ^{136}Te

Comparison of experimental values for B(E2; $I_i \to I_f$) (e^2b^2) for ^{136}Te

$0_1^+ \to 2_1^+$	$2_2^+ \to 0_1^+$	$2_2^+ \to 2_1^+$	$4_1^+ \to 2_1^+$	Reference
0.122(18)				Danchev et al. [8]
0.122(24)				Fraile et al. [28]
0.191(26)	≤0.0038		0.061(31)	Vaquero et el. [12]
0.181(15)	≤0.004	≤0.09	0.060(9)	Allmond et al. [11]

- No lower value for B(E2; $2_1^+ \to 0_1^+$)
- No enhanced B(E2; $2_2^+ \to 0_1^+$)



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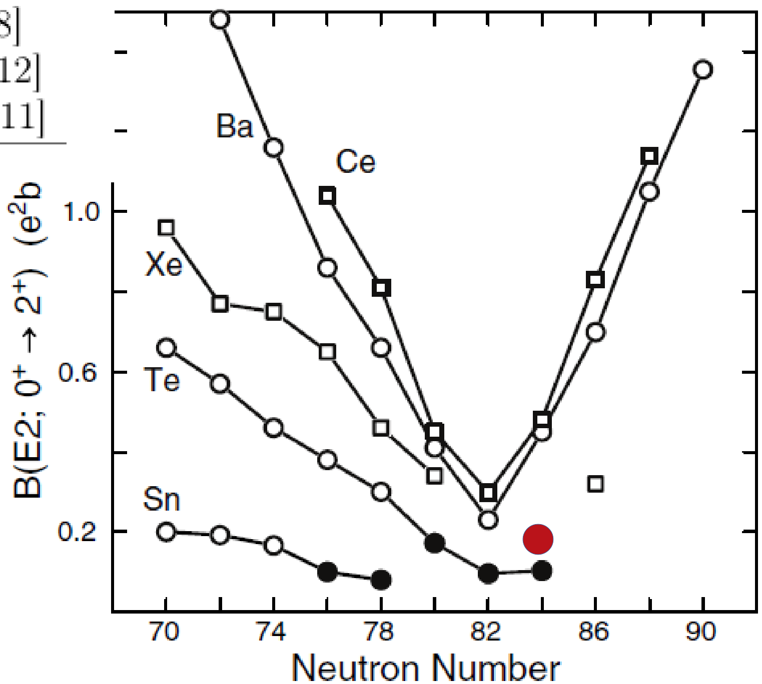


Still an important piece of information missing – B(M1; 2_2^+-> 2_1^+)

Mixed Symmetry States

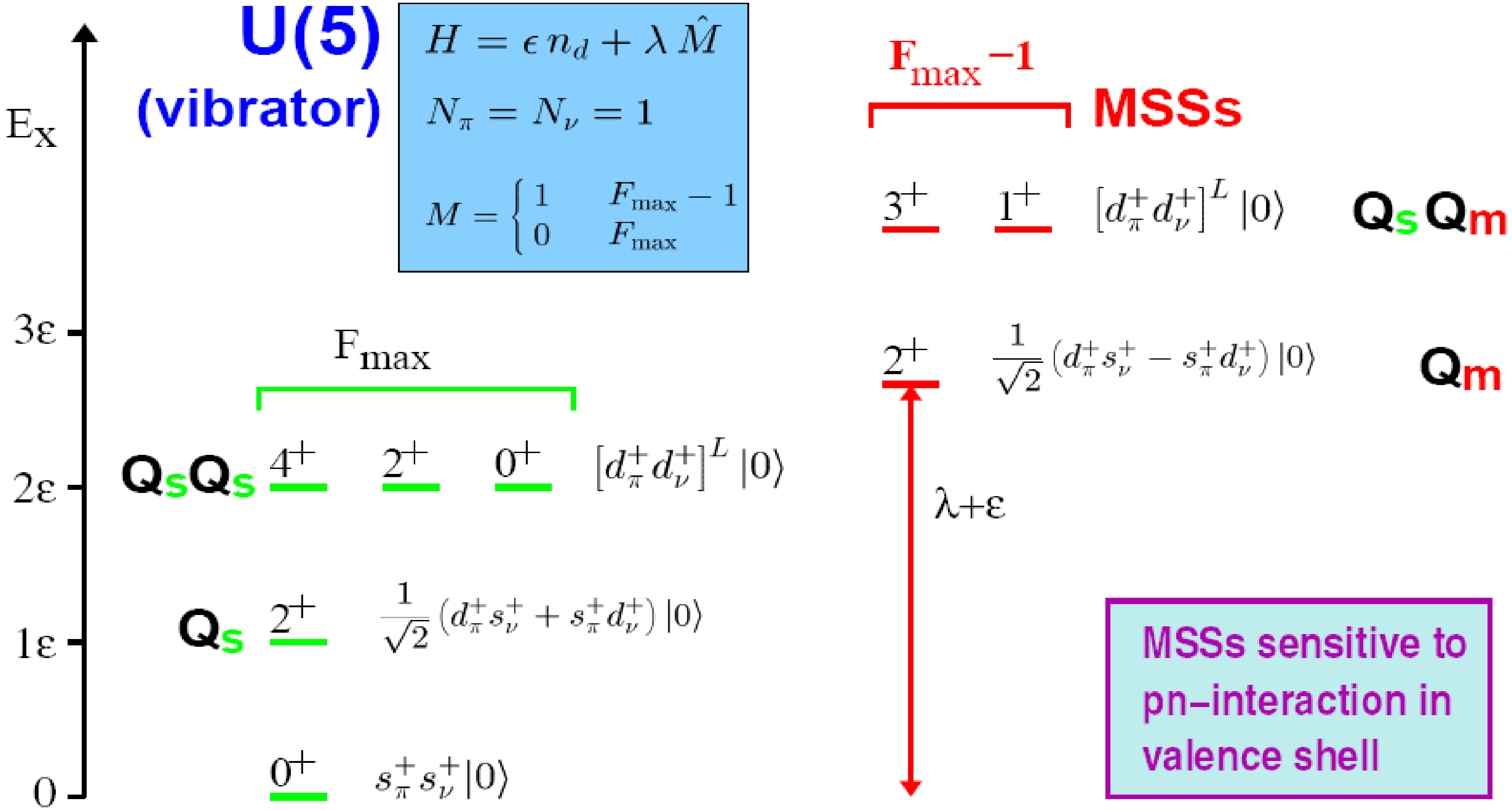
Example: Hamiltonian Spectrum with 2 valence particles (IBM-2 A. Arima, F. Iachello)

U(5) (vibrator)

$$H = \epsilon n_d + \lambda \hat{M}$$

$$N_\pi = N_\nu = 1$$

$$M = \begin{cases} 1 & F_{max} - 1 \\ 0 & F_{max} \end{cases}$$



MSSs sensitive to pn–interaction in valence shell

Mixed Symmetry States

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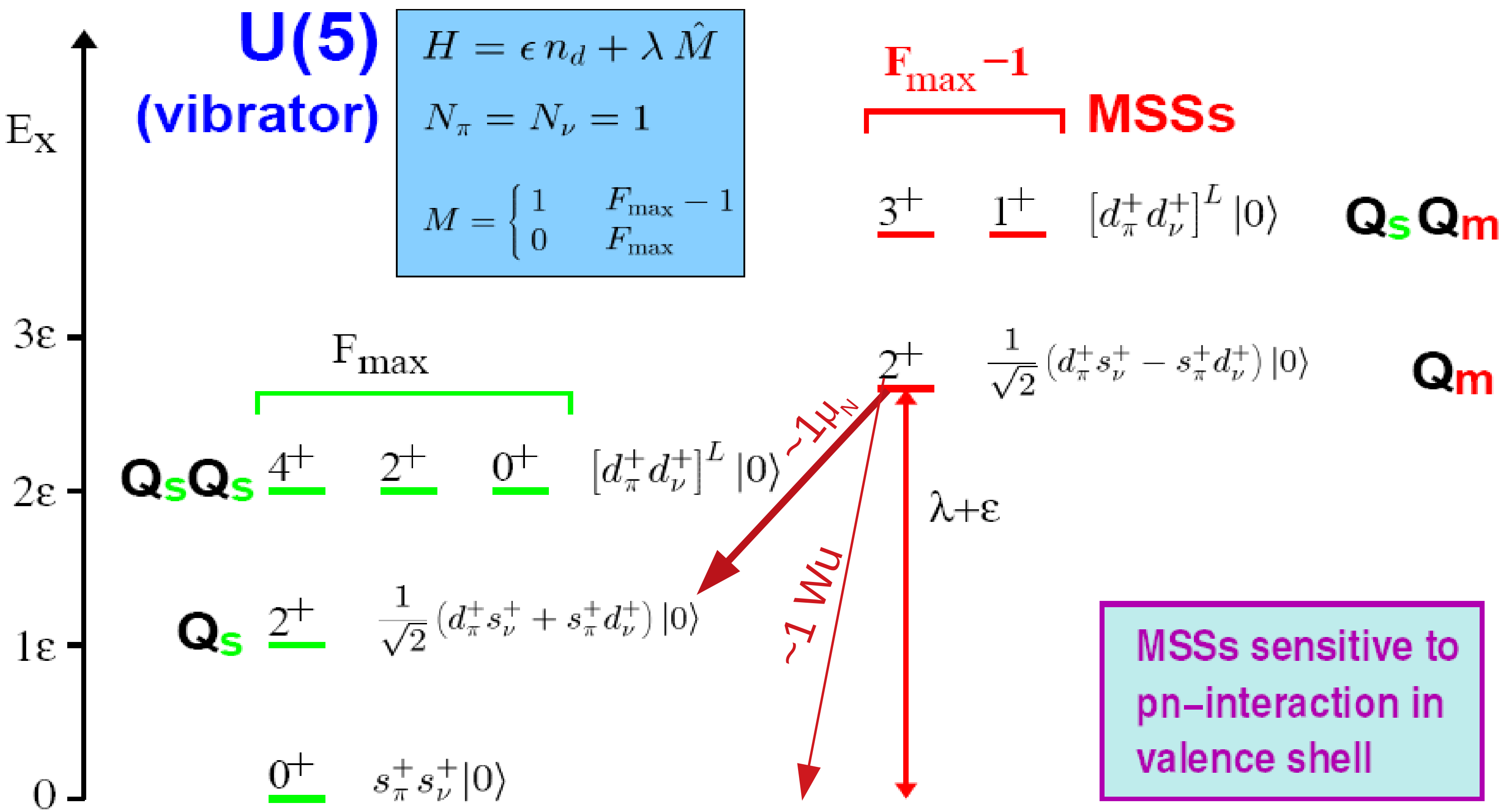
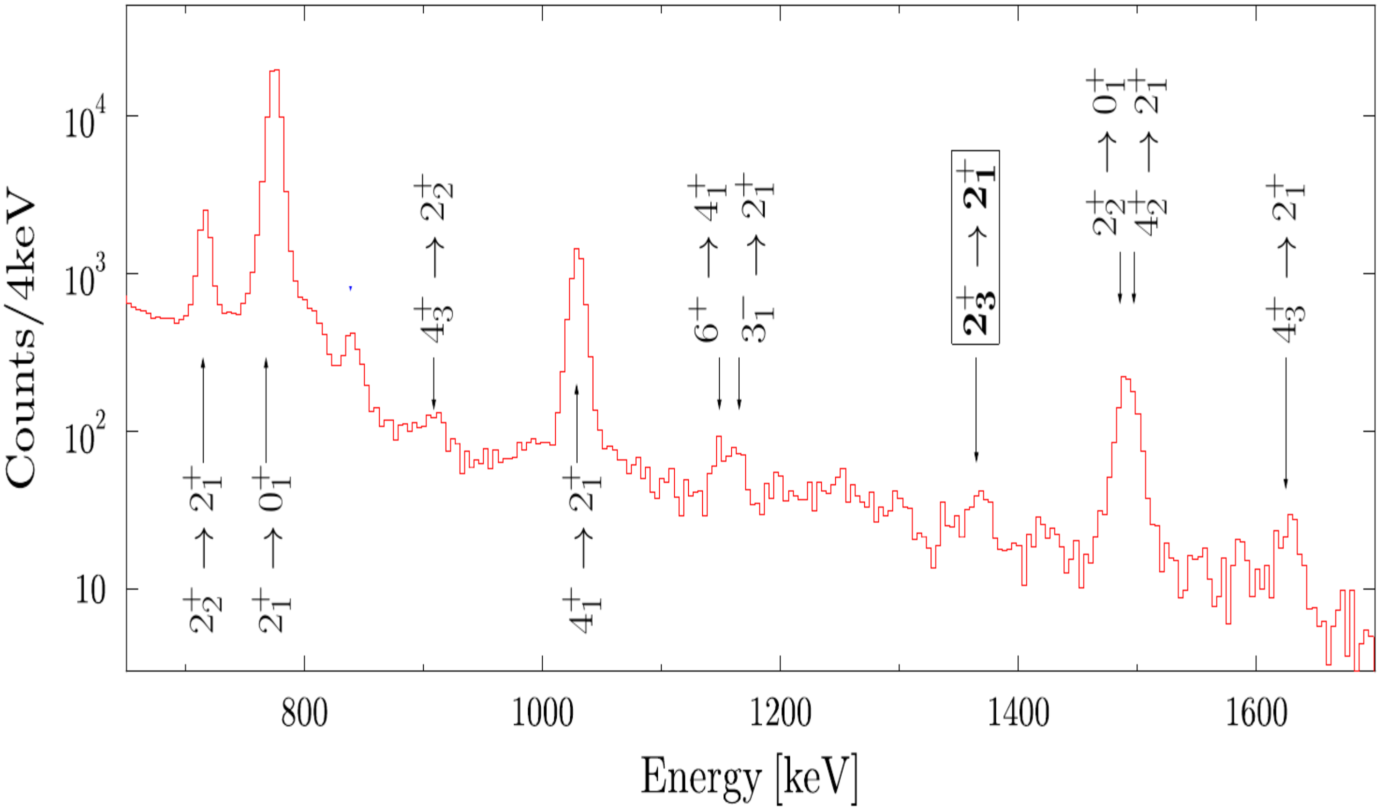


MSS identified using RIBs @ ISOLDE



^{140}Nd(4.62 MeV/u) on 1.45 mg/cm^2 ^{208}Pb

MINIBALL + DSSSD

GOSIA calculations

~16 hours beamtime

R. Kern, R. Zidarova , to be published

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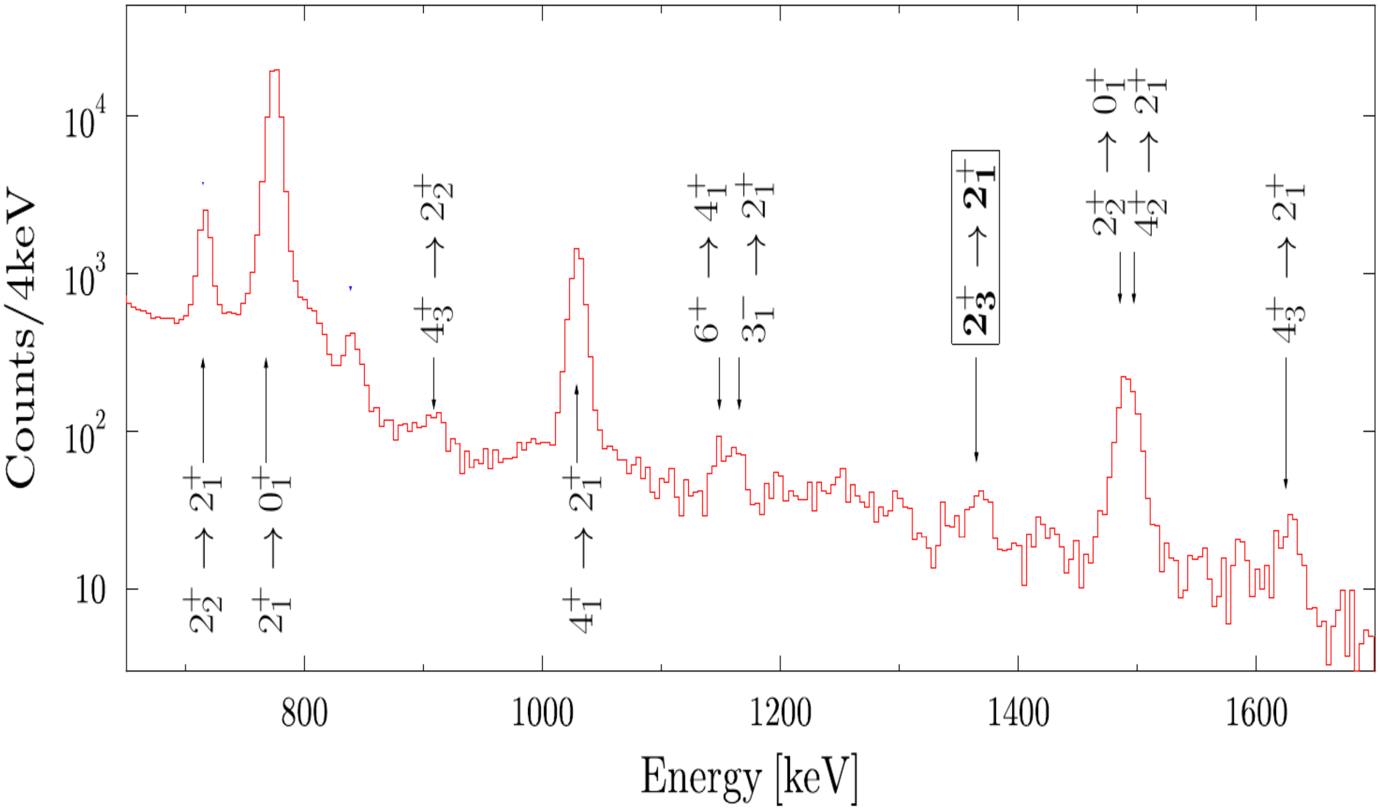

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$B(M1; 2_3^+ \rightarrow 2_1^+) = 0.245^{+0.057}_{-0.041}$

R. Kern, R. Zidarova , to be published

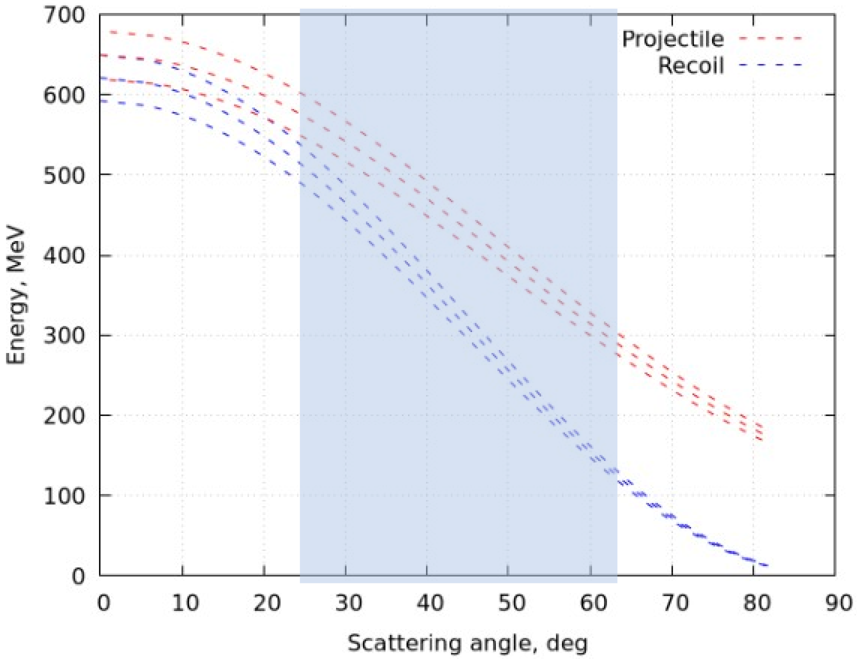
MSS in 136Te: Proposed Experiment

Measurement of M1 matrix element and branching ratio

$$BR \approx \frac{\Gamma_{E2;2_2^+ \to 0_1^+}}{\Gamma_{M1;2_2^+ \to 2_1^+}}$$

MINIBALL detector array for gamma ray detection + DSSSD for particle identification

Calculated particle spectrum in the DSSSD detector



Proposed Experiment

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^{136}Te beam:

- TAC Comments: Development work to determine contaminants, LIST and VADLIS tests
- RILIS scheme developed for Te isotopes
- LIST candidate isotope → beam intensity reduction by a factor of 30-50

Request

- ^{136}Te ion beam ~ 10^4 – 10^5 pps
- 680 MeV (5 MeV/u)
- ^{208}Pb target, 2.5 mg/cm^2 for Coulex
- MINIBALL array + DSSSD
- 9 shifts (3 days) - beam analysis + data run
- Estimated Yield 2_2^+ : 175 counts/day

Thank you for the attention!

Branching ratio prediction

$B(M1;2_2^+ \rightarrow 2_1^+)=0.2\ \mu_N$
$B(E2;2_2^+ \rightarrow 0_1^+)=1/2(\text{upper limit}) = 0.004\ e^2b^2$

$\delta \approx 0$

→ $$\Gamma_{total} = \Gamma_{M1} + \Gamma_{B2}$$

→ BR=0.18

→ ≈ 30 counts/day in $2_2^+ \rightarrow 0_1^+$

Estimated Count rates

Level	Energy, keV	Cross section, mb	Yield (cts/day)
2_1^+	606	$2.46.10^3$	7692
4_1^+	1030	$1.24.10^2$	387
2_2^+	1568	$5.61.10^1$	175

Estimated cross sections and count rates for projectile Coulomb excitation of ^{136}Te on 2.5 mg/cm^2 Lead target. Gamma ray detection efficiency assumed to be 5%, beam intensity 10^5 pps.

Matrix elements used in the CLX calculations

Transition	Matrix element, eb
$0_1^+ \rightarrow 2_1^+$	0.42
$0_1^+ \rightarrow 2_2^+$	0.1
$2_1^+ \rightarrow 4_1^+$	0.73
$Q(2_1^+)$	-0.45
$2_1^+ \rightarrow 2_2^+$ (M1)	1.0 μ_N^2

TAC comments

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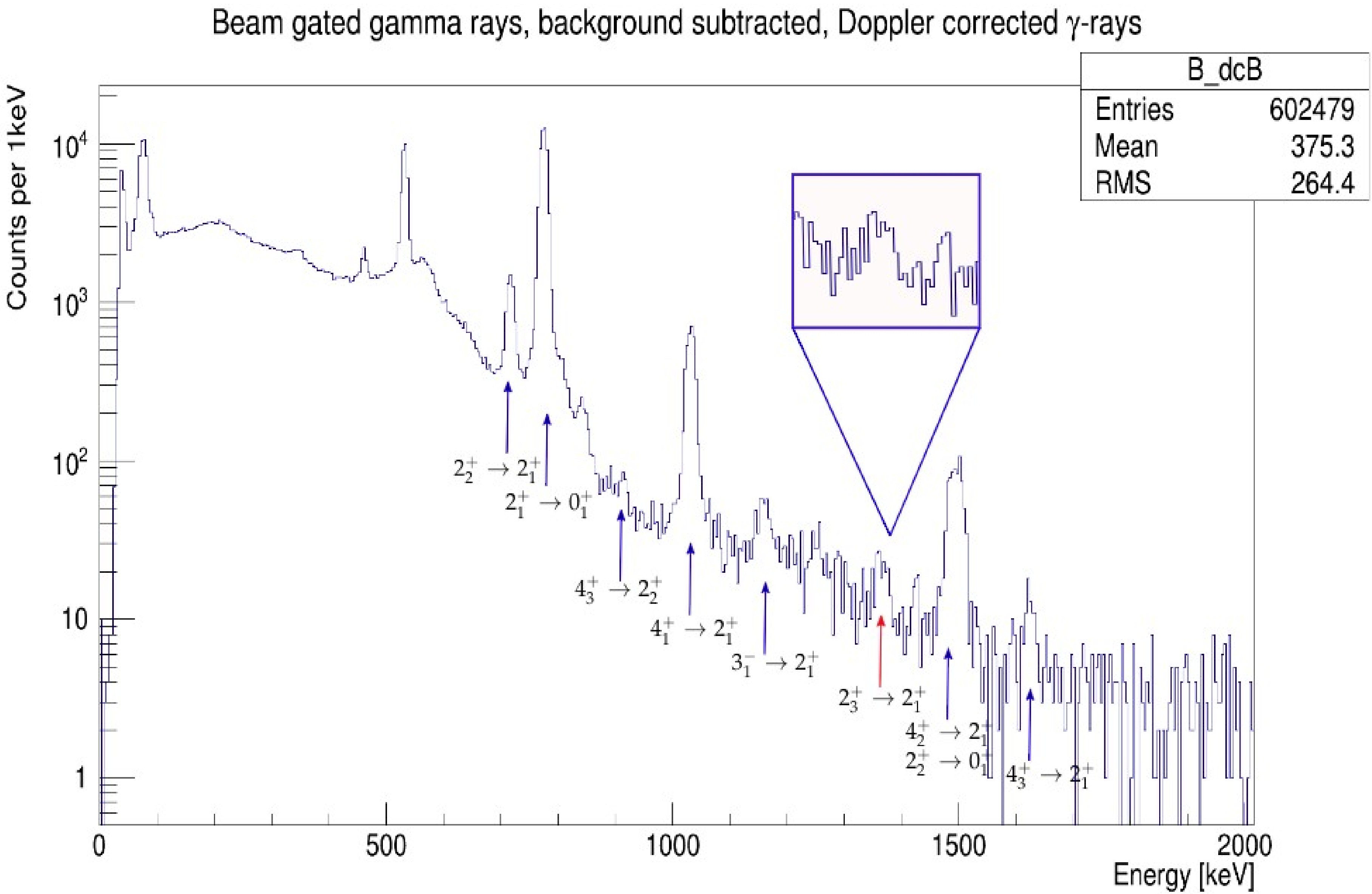
2 + Anomaly and Configuration Isospin Polarization of 136Te					
Status report #	**Proposal #**	**IS #**	**Setup**	**Shifts**	**Isotopes**
INTC-SR-079	INTC-P-421	IS596	Miniball	9	136Te
Beam intensity/purity, targets-ion sources	A yield of 4E7 ions /uC from Uc and MK5 at SC has been measured. A more recent yield of 5.4e6 ions/s has been found (with RILIS), but heavily contaminated with Cs. With the LIST ion source a factor of ~ 30 reduction in-source can be expected. Therefore this is a LIST candidate isotope if the users can still run with a factor 30 lower rate of 136Te. Cs suppression levels need to be checked. New RILIS scheme developed, efficiency>18%. Laser ionization in SI+LIST (20-50x efficiency loss). VADIS (VADLIS) could also be applied. The adjustable extraction vadlis may give ~3x improvement in efficiency wrt standard VADLIS, but needs to be verified. VADIS could give suppression of Cs (as seen offline), to be demonstrated on-line.				
General implantation and setup					
REX, HIE-ISOLDE	Isotope: 136Te (RILIS+LIST (x20-50 yield reduction) Possible beam: 136Te33+ Half-life: 17.63 s Intensity: 4E7/uC out of the target (before LIST reduction), 1E4-1E5 pps at Miniball Contaminants: 136Xe (8.8% abundance) Energy: 5 MeV/u Shifts: 12 Miniball				
General Comments					
Safety	Nothing additional to MINIBALL set-up (safety clearance 2017 EDMS 1806701)				
TAC recommendation	**The TAC recommends that some development work is carried out to determine if the Cs which will be present on mass 136 can be suppressed. This would take the form of LIST tests and also VADLIS. Can the users still run in the requested number of shifts if the original rate of 136Te is reduced by a factor of ~30? (but is essentially free of Cs?)**				



Beam gated gamma rays, background subtracted, Doppler corrected γ-rays
B_dcB
Entries 602479
Mean 375.3
RMS 264.4
Counts per 1keV
Energy [keV]
$2_2^+ \to 2_1^+$
$2_1^+ \to 0_1^+$
$4_3^+ \to 2_2^+$
$4_1^+ \to 2_1^+$
$3_1^- \to 2_1^+$
$2_3^+ \to 2_1^+$
$4_2^+ \to 2_1^+$
$2_2^+ \to 0_1^+$
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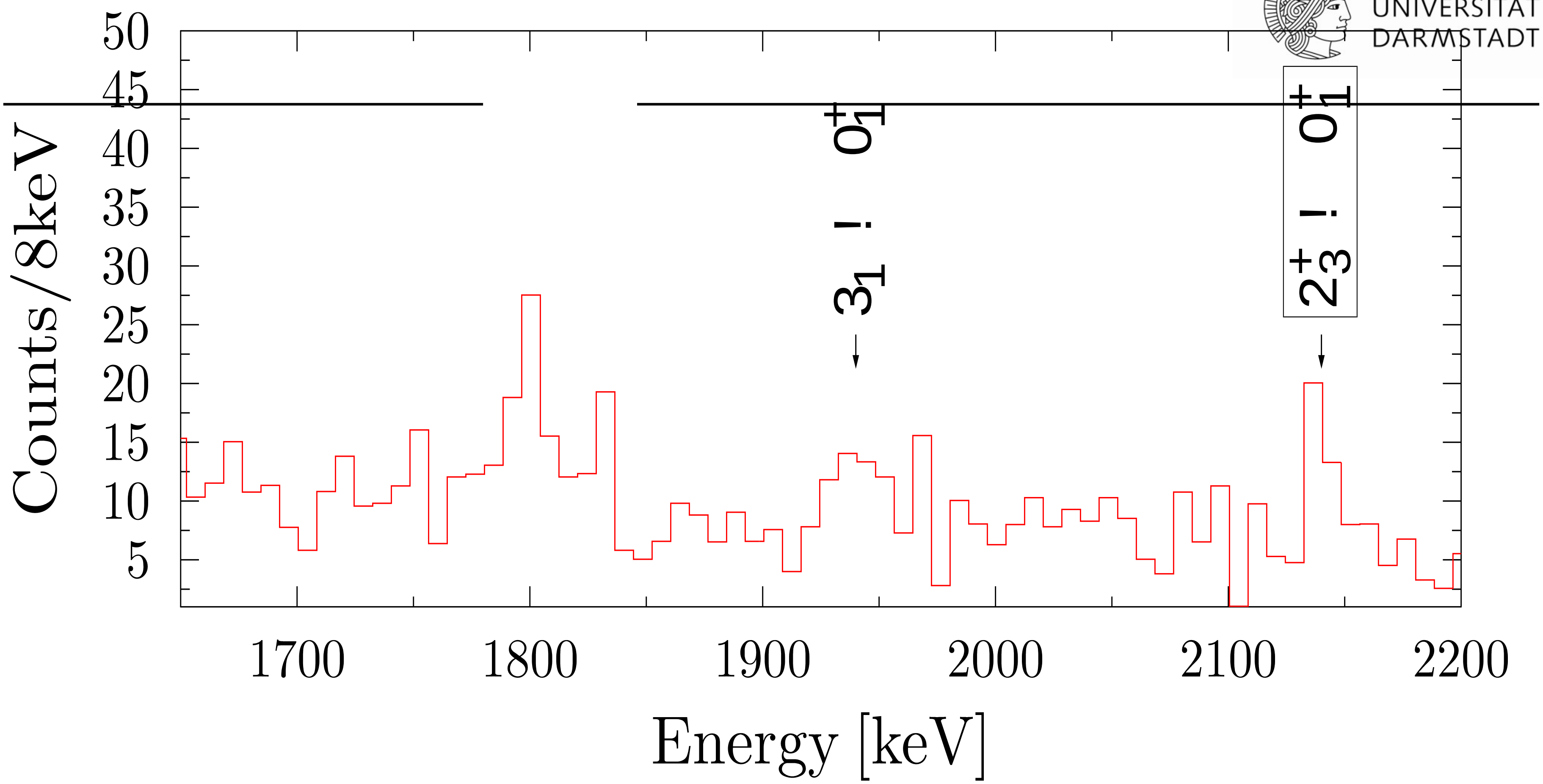
50
45
40
35
30
25
20
15
10
5
Counts/8keV
1700
1800
1900
2000
2100
2200
Energy [keV]
3_1 ! 0_1^+
2_3^+ ! 0_1^+

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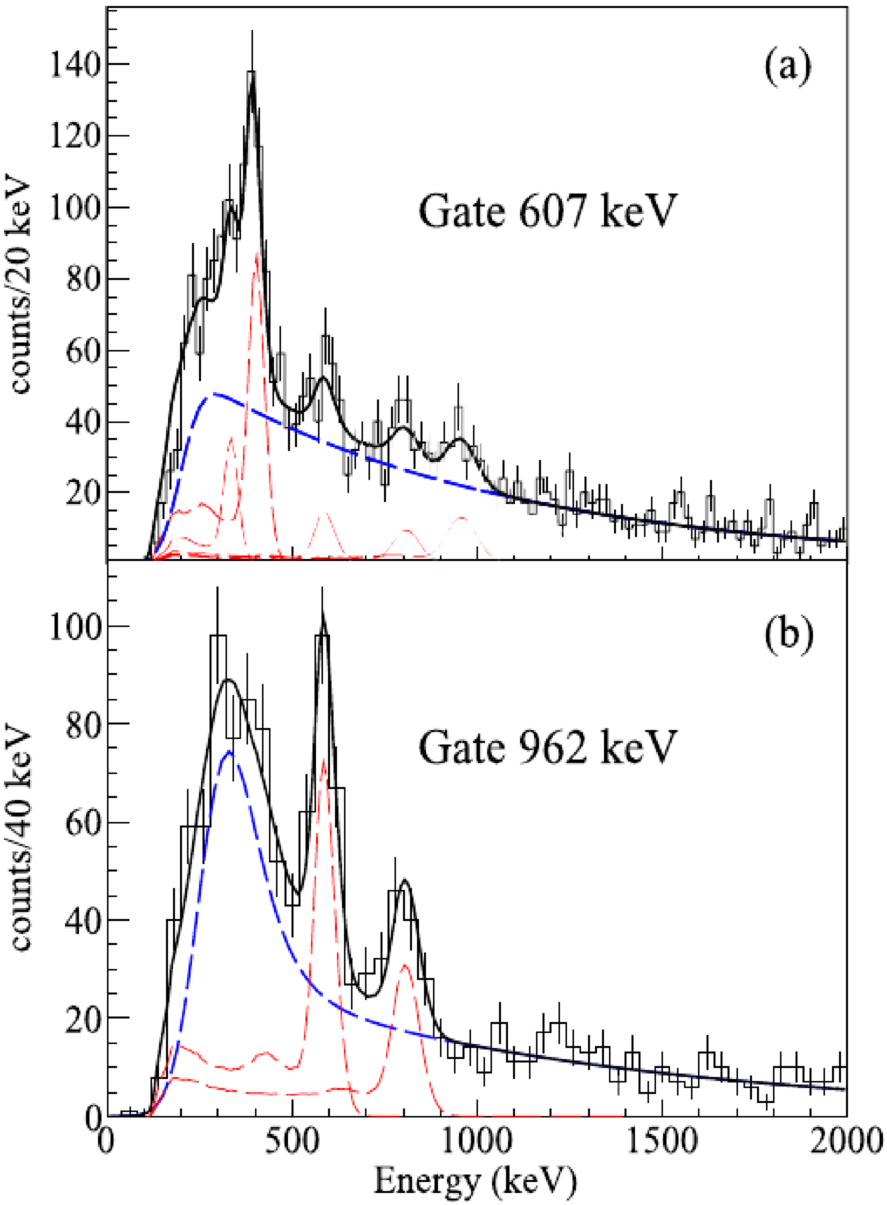

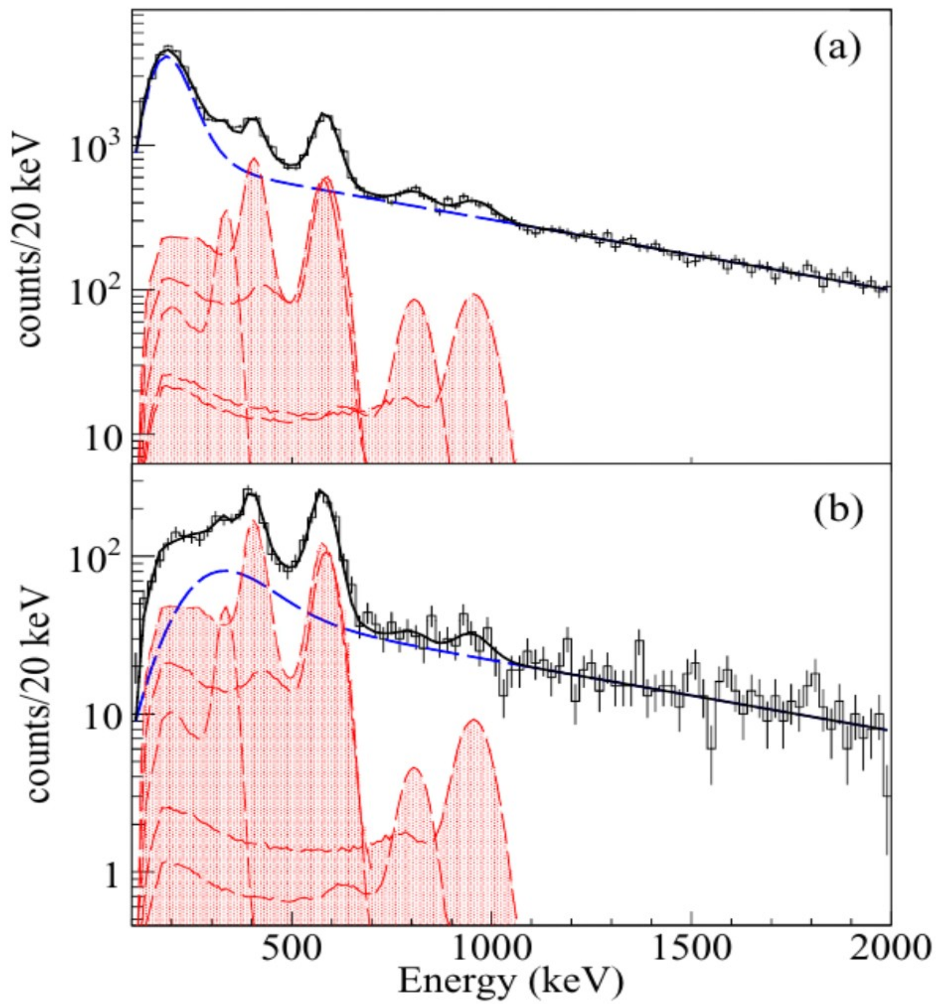

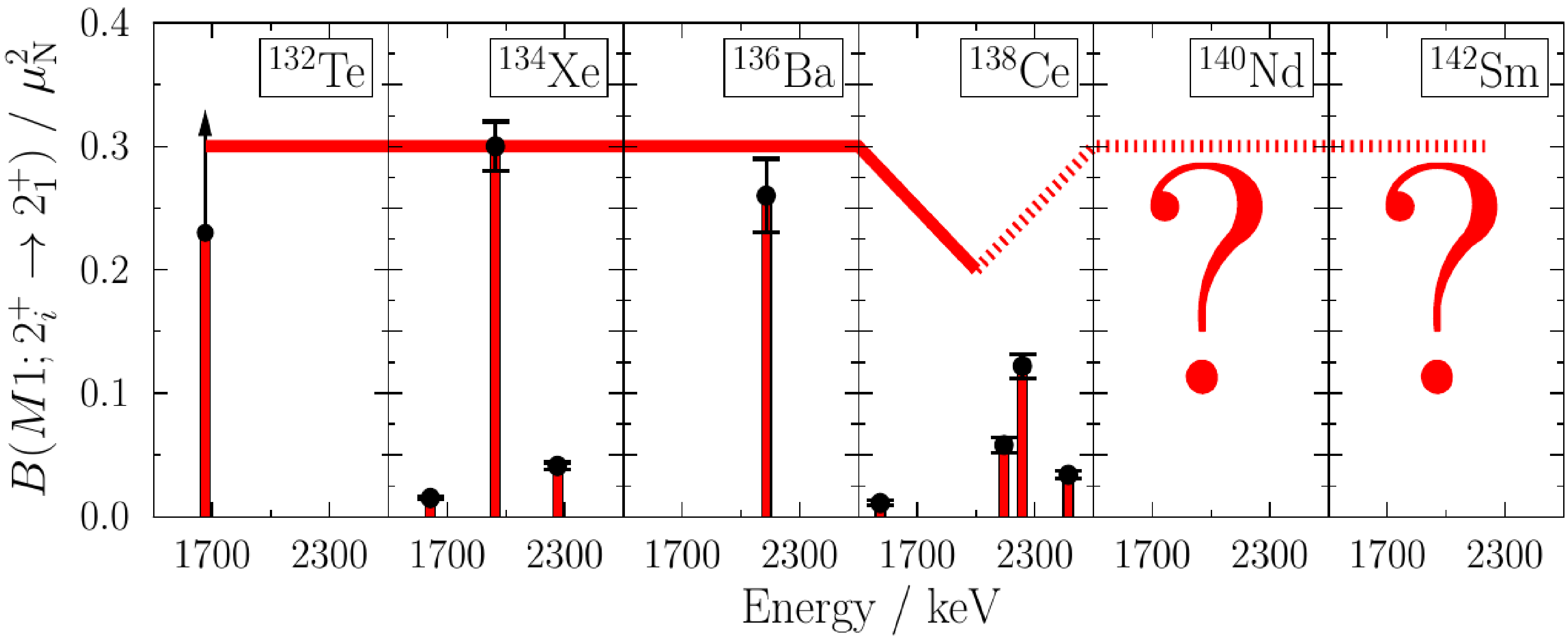

Systematics of the known $B(M1;2_i^+ \rightarrow 2_1^+)$ for the N=80 isotonic chain