Proton-neutron balance of properties of ^{136}Te

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Proposed Experiment

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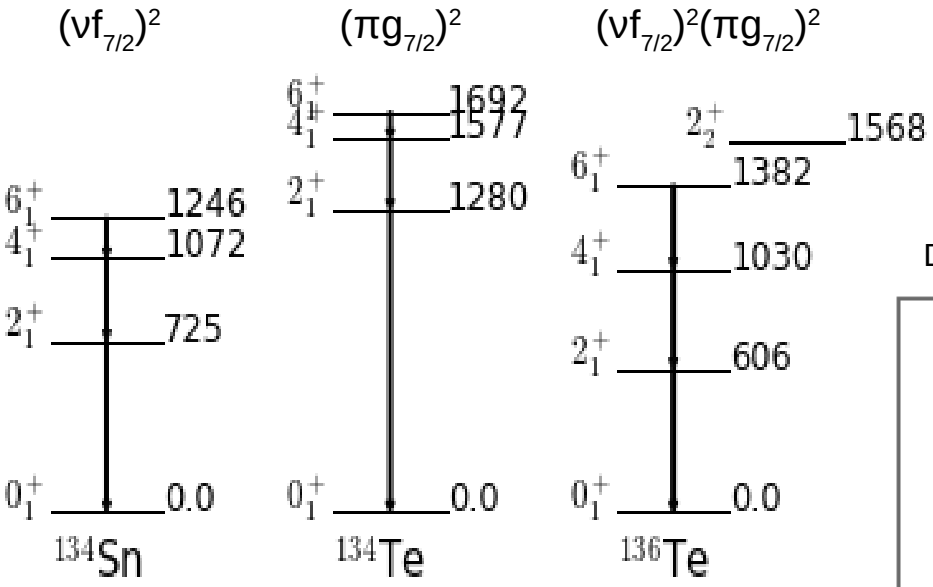
Goals:

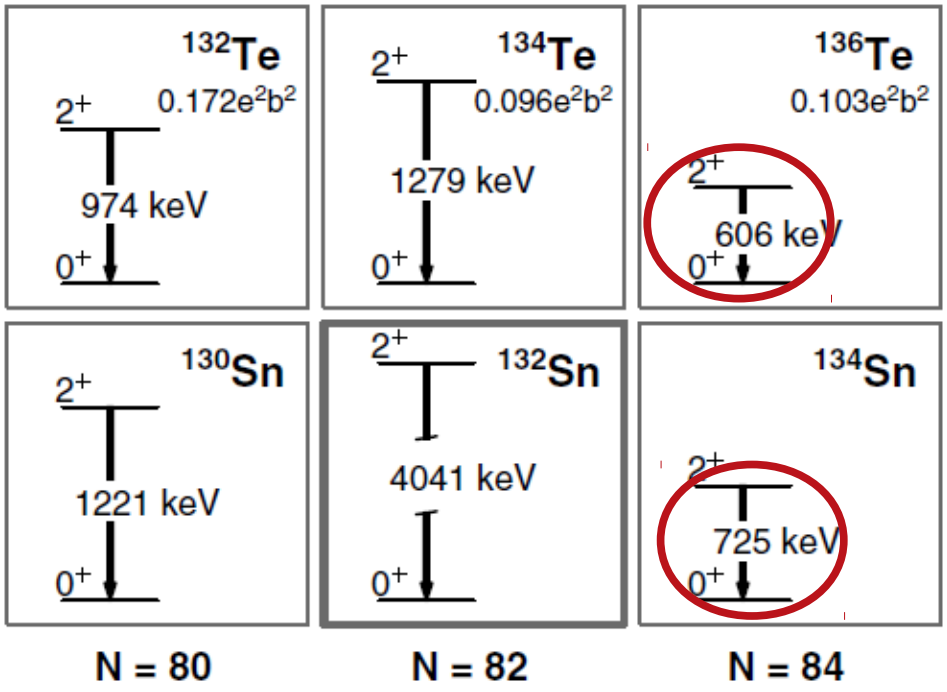
- Development of post-accelerated Te ion beams;
- Investigating the proton-neutron balance of the properties of the excited states in ^{136}Te by measurement of the B(E2) of 2^+_1 state;
- Probing the mixed-symmetry character of the 2^+_2 state by measurement of the transition probability.

Physics case



Lower energy of the first excited state – hints at unbalanced proton-neutron contribution in WF

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



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

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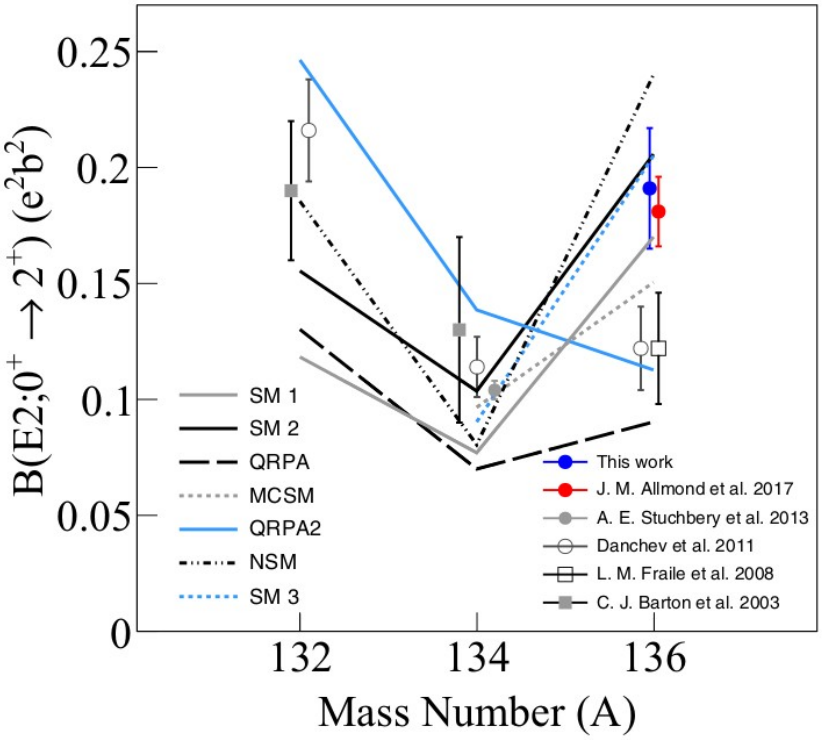
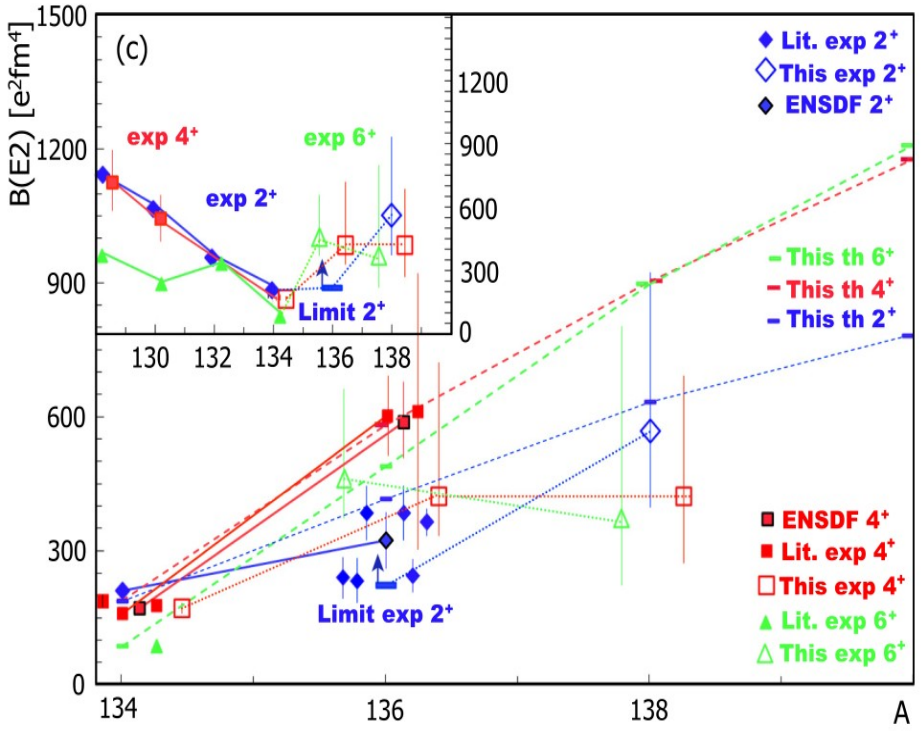
Contradicting information on the character of the 2_1^+ state



V. Vaquero et al., PRC 99, 034306 (2019)



G. Häfner, R. Lozeva et al., PRC 103, 034317 (2021)

Physics case

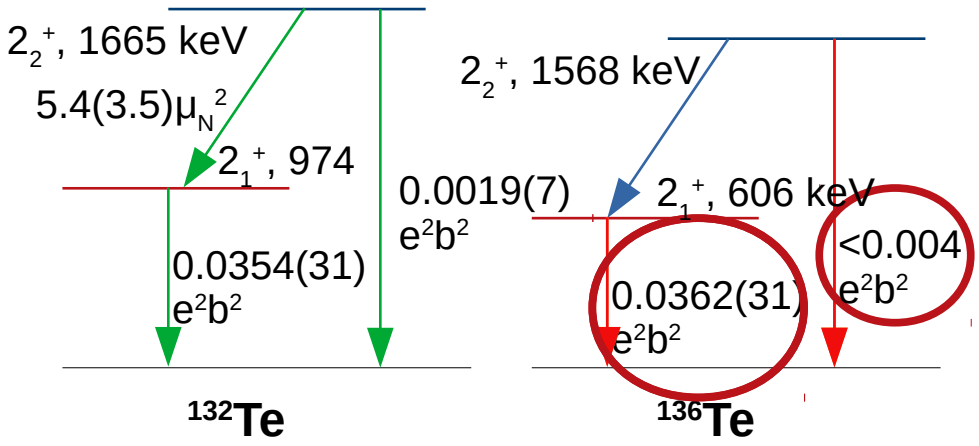
Two state proton-neutron mixing:

$\Psi_I = \alpha\Phi_1 + \beta\Phi_2$,
$\Psi_{II} = -\beta\Phi_1 + \alpha\Phi_2$

Mixed Symmetry States – antisymmetric under exchange of p-n pair

Experimental observables:

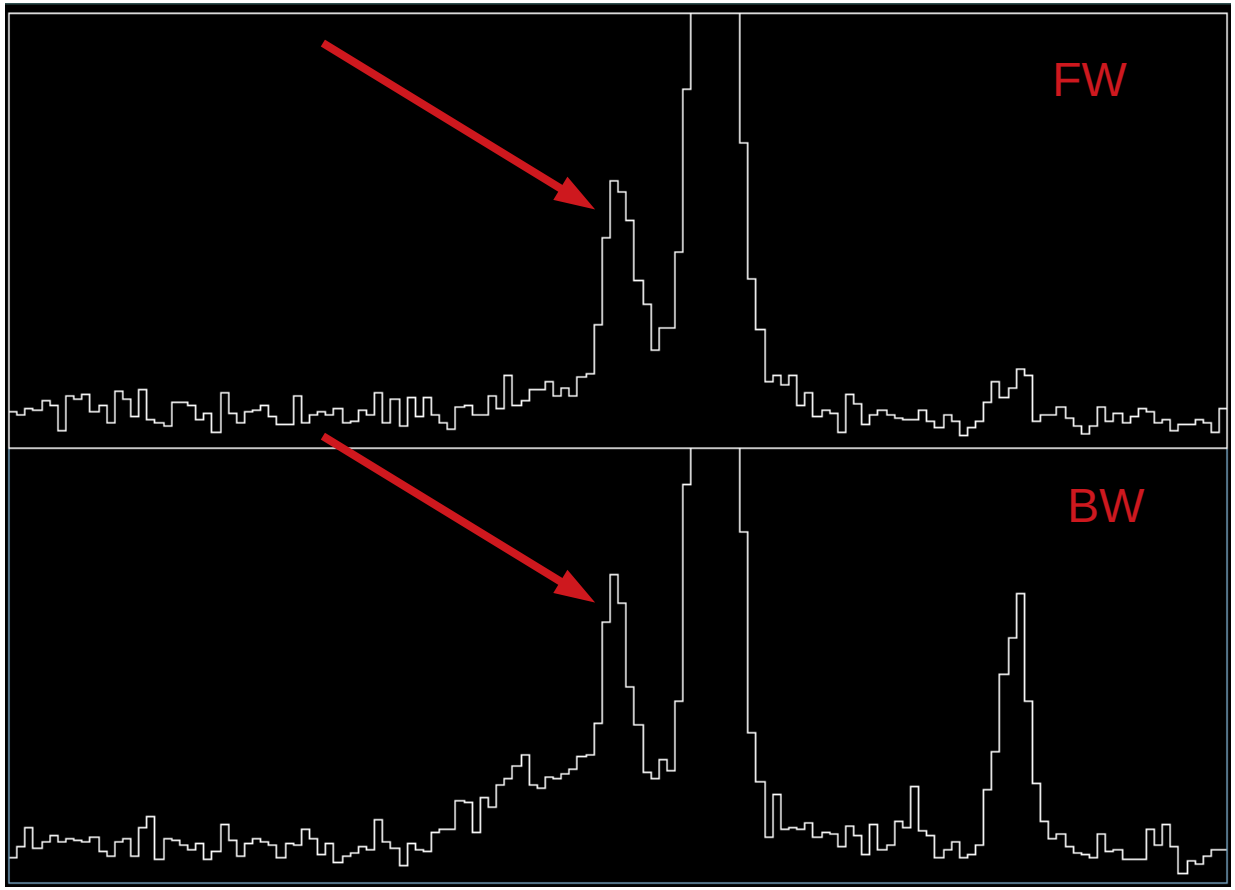
- Large B(M1) to underlying FSS – 1 μ_N
- Weakly collective B(E2) to GS – 1 Wu
- Short-lived



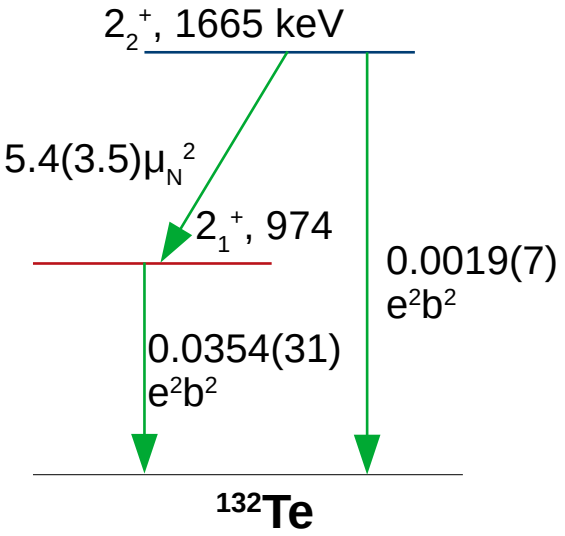
M. Danchev et al., PRC 84, 061306 (2011)
V. Vaquero et al., PRC 99, 034306 (2019)
J. M. Allmond et al., PRL 118, 092503 (2017)

Key Observables for the one-phonon mixed-symmetry 2+ state of ^{132}Te
***R. Zidarova, V. Werner**, N. Pietralla*
Experiment performed June '21 at IFIN, Bucharest

Physics case

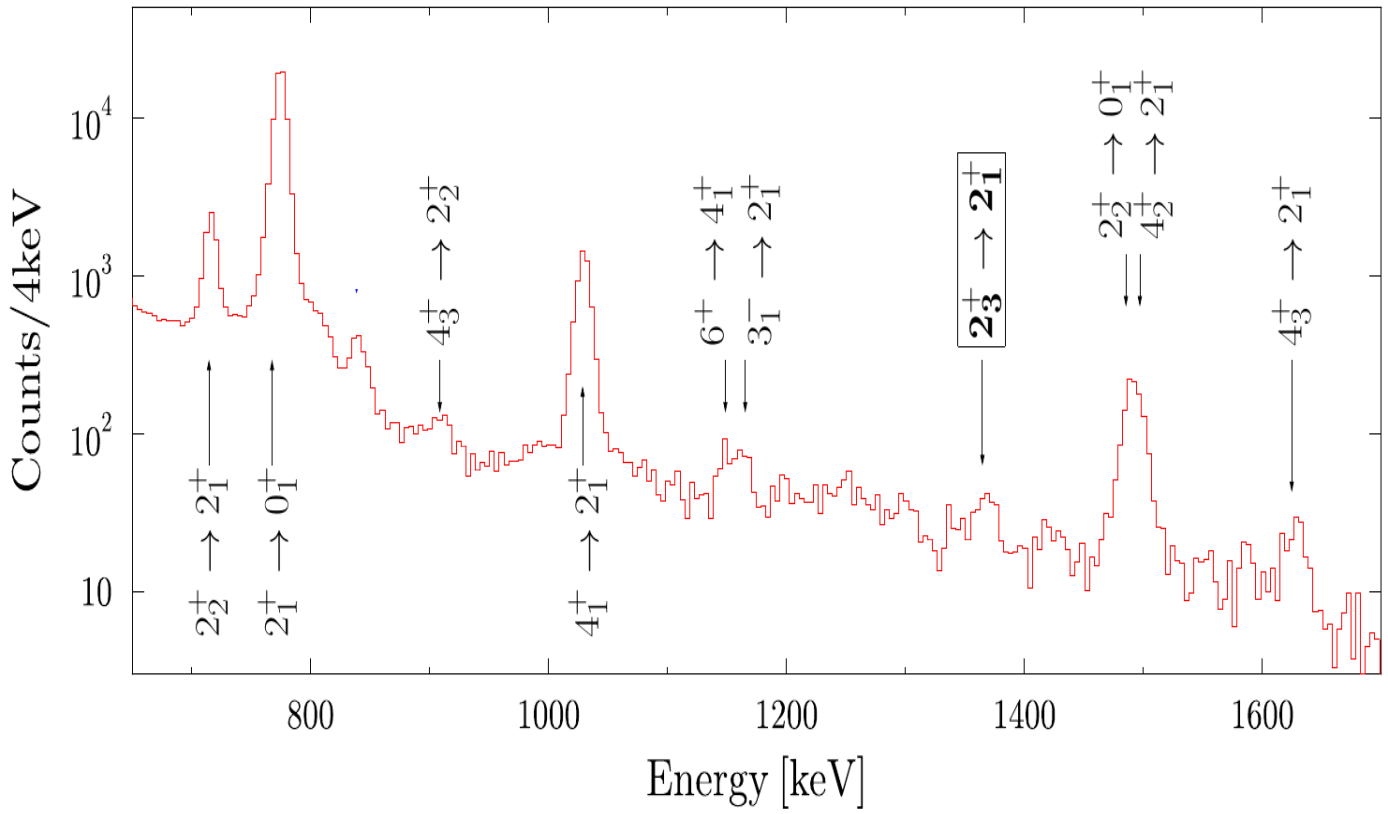


130Te(18O,16O)132Te @ IFIN-HH



132Te – Preliminary spectrum
Forward angle vs. Backward angle detected γ-rays
→ Distinct lineshape → hundreds of fs lifetime

MSS identified using RIBs @ ISOLDE



R. Kern, R. Zidarova et al., Phys. Rev., C 102, 041304(R) (2020).

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

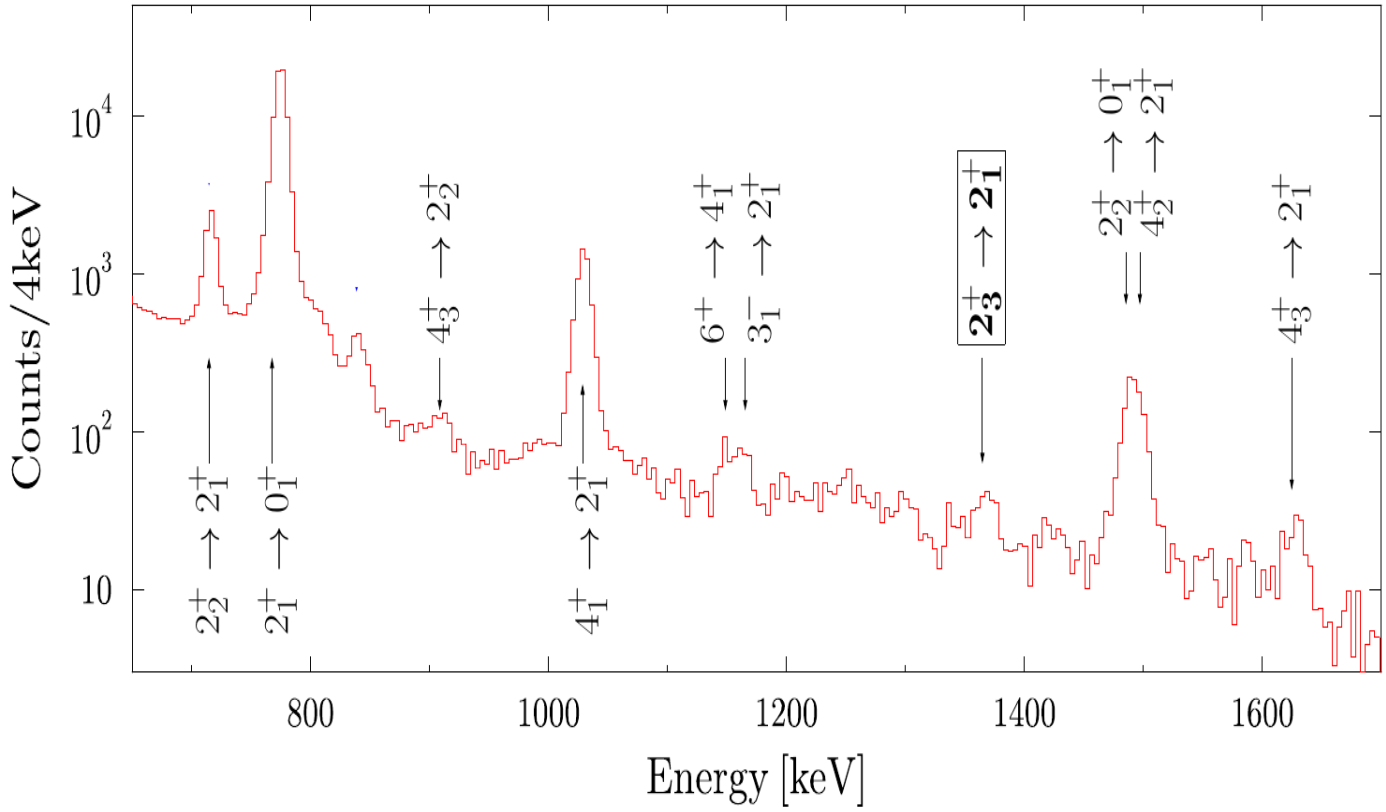
MINIBALL + DSSSD

GOSIA calculations

~16 hours beamtime

→ ~ 100 counts in beam-gated spectrum

MSS identified using RIBs @ ISOLDE



R. Kern, R. Zidarova et al., Phys. Rev., C 102, 041304(R) (2020).

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~16 hours beamtime

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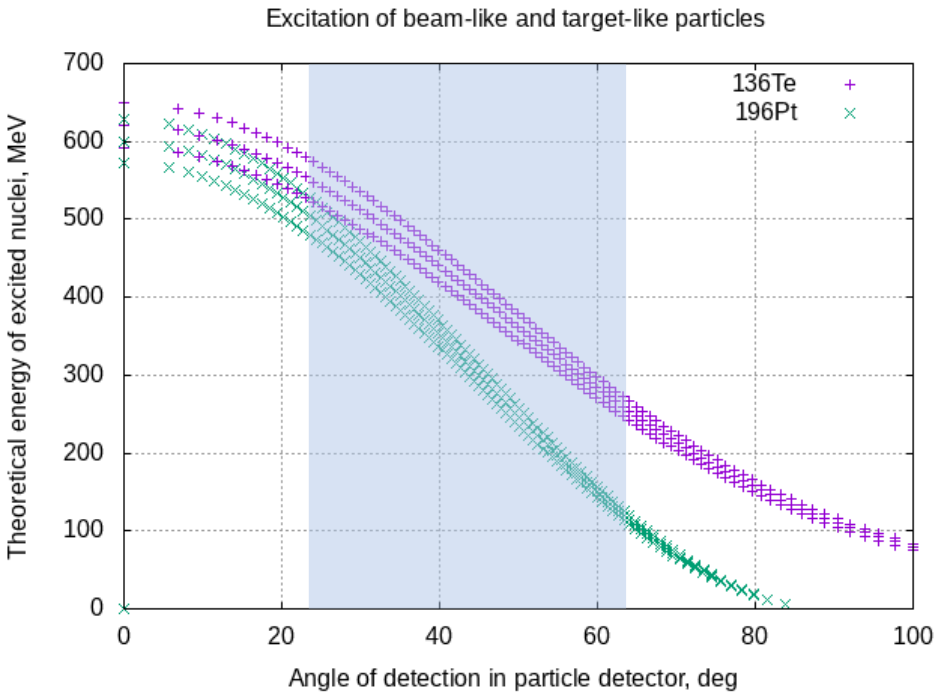
$B(M1;2_3^+ \rightarrow 2_1^+) = 0.245^{+0.057}_{-0.041}$

Request

- ^{136}Te ion beam (assumed 10^5 pps)
- 640 MeV (4.7 MeV/u)
- ^{196}Pt target, 2 mg/cm^2 for Coulex
- MINIBALL array + DSSSD
- Estimated Yield 2_2^+: 86 counts/day
- Angular correlations
- 15 shifts (5 days)

Calculated particle spectrum in the DSSSD detector



TAC Comments

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Proton-neutron balance in the properties of 136Te					
CDS#	**Proposal #**	**IS #**	**Setup**	**Shifts**	**Isotopes**
CERN-INTC-2021-029	INTC-P-600		Miniball	15	136Te
Beam intensity/purity, targets-ion sources	There are several inaccurate assumptions in the calculation of the yield in the proposal. The yield for 136Te is taken from the SC data where a value of 1e4 - 1e5 ions / sec is estimated at the secondary target, primary yield of 4e7/uC. ABRABLA predicts a yield 1.5 times less than SC with 1.4GeV protons. RILIS in the LIST mode will be required to suppress 136Cs. A recent measurement without LIST measured 136Te at 5.4 e6 /uC. With a LIST unit this could be expected to be 1e5/uC, which would translate to an upper limit yield of 1e4 ions/s at the secondary target. The required number of shifts may need to be re-evaluated with these updated figures.				
HIE-ISOLDE	The requested beam is 136Te (t1/2=17.5 s) at an energy of 4.7 MeV/u. There will be some contamination of 136Ce from cathode and 136Xe from EBIS, although the levels are expected to be quite low and should not affect the experiment. However, the production of 136Te with LIST would reduce its intensity so this should be borne in mind. LIST will have to be working efficiently to suppress the Cs from the target. If Cs can be controlled, the technical aspects for post-acceleration should not be an issue.				
General implantation and setup	Potential source of prompt radiation.				
General Comments					
Safety	Safety clearance of MINIBALL experiment can be found at 1806701. The ISIEC form needs to be updated and an electrical inspection to be performed before start of the experiment. No additional hazards brought by this experiment.				
TAC recommendation	**The TAC notes that the production of 136Te may be lower than expected and with the LIST ion source a value of 1e4 at the target may be the upper value expected. The requested number of shifts may need to be re-evaluated with this in mind.**				

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Thank you for the attention!

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Back-up

Estimated Count rates

Level	Energy, (keV)	Cross section, (b)	Yield (cts/day)
2_1^+	606.6	1.8761	4980
4_1^+	1030.0	0.06519	172.8
2_2^+	1568.4	0.03264	86.64

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

Table 1: Comparison of the experimental values for transition probabilities $B(E2; I_i \rightarrow I_f), [e^2b^2]$ of ^{136}Te

$0_1^+ \rightarrow 2_1^+$	$2_2^+ \rightarrow 0_1^+$	$2_2^+ \rightarrow 2_1^+$	$4_1^+ \rightarrow 2_1^+$	$6_1^+ \rightarrow 4_1^+$	Reference
0.122(18)					Danchev et al. [22]
0.122(24)					Fraile et al. [27]
0.191(26)	< 0.0038		0.061(31)		Vaquero et el. [31]
0.181(15)	< 0.004	< 0.09	0.060(9)		Allmond et al. [30]
> 0.110			$0.042^{+0.03}_{-0.009}$	$0.046^{+0.02}_{-0.009}$	Lozeva et al. [25]

Matrix elements used in the CLX calculations

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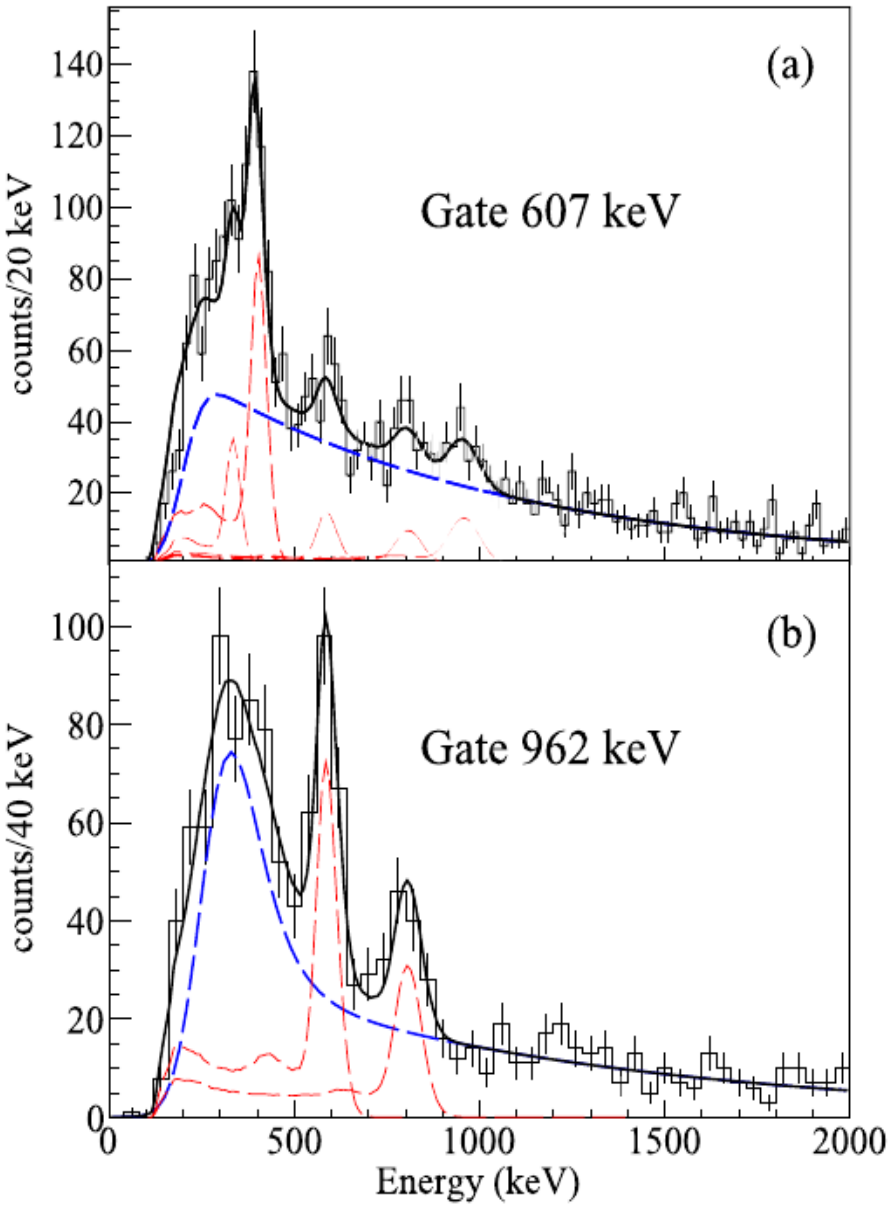
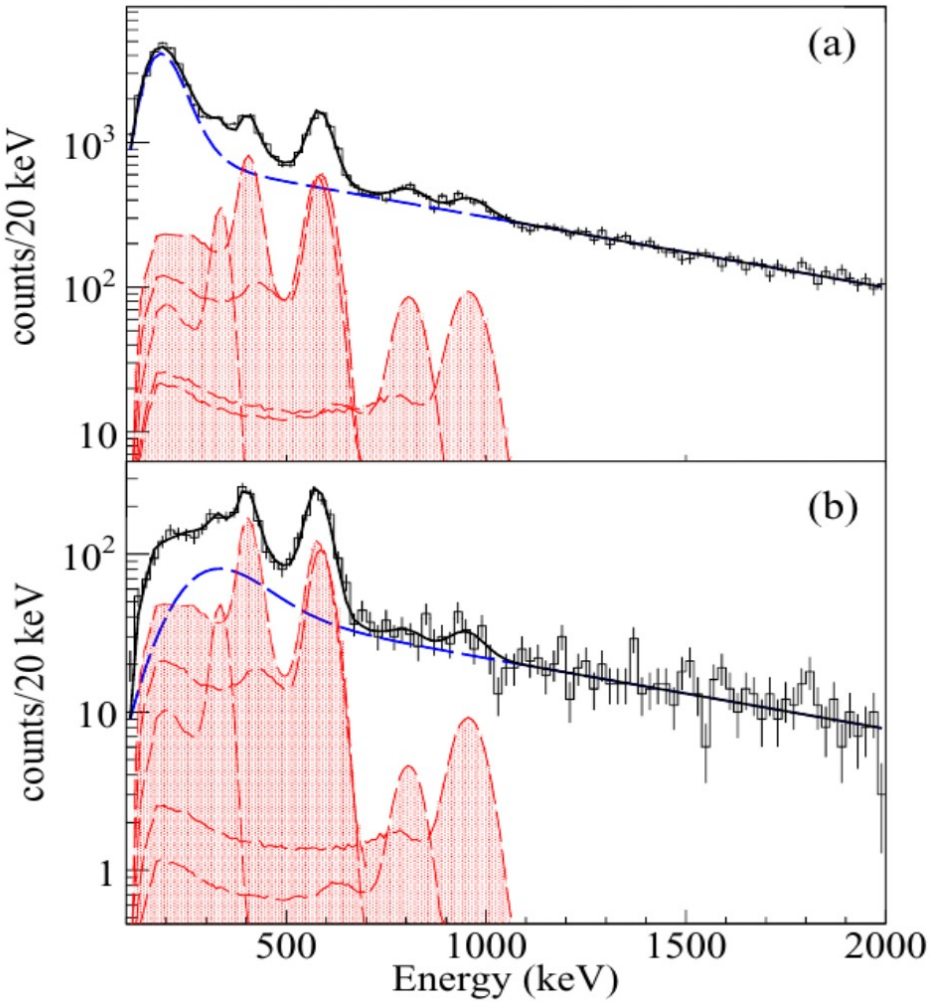
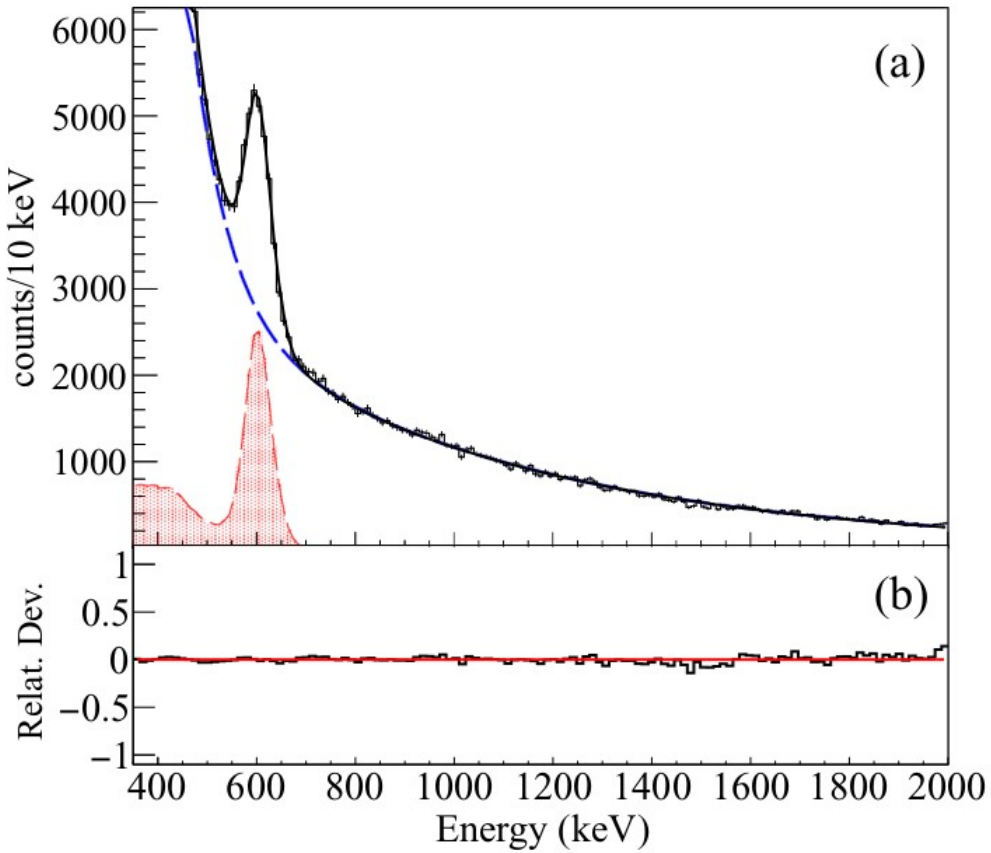
Transition	Matrix element, eb
$0_1^+ \rightarrow 2_1^+$	0.42
$0_1^+ \rightarrow 2_2^+$	0.1
$2_1^+ \rightarrow 4_1^+$	0.73
$Q(2_1^+)$	-0.45
$2_1^+ \rightarrow 2_2^+$ (M1)	1.0 μ_N^2


(a)
Gate 607 keV
counts/20 keV
(b)
Gate 962 keV
counts/40 keV
Energy (keV)


(a)
counts/20 keV
(b)
counts/20 keV
Energy (keV)


(a)
(b)
counts/10 keV
Relat. Dev.
Energy (keV)
6000
5000
4000
3000
2000
1000
1
0.5
0
−0.5
−1
400
600
800
1000
1200
1400
1600
1800
2000