Coulomb excitation close to ^{100}Sn

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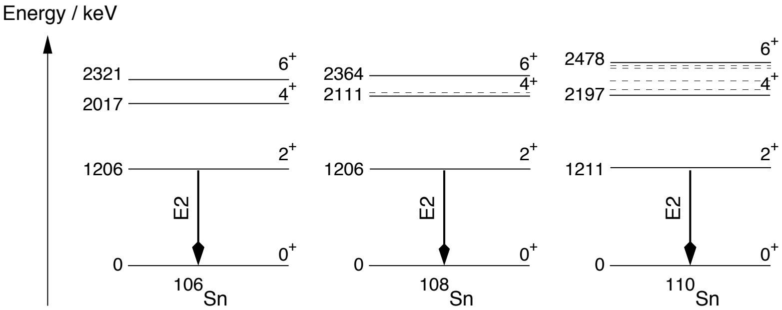
May 3, 2010

Lund-GSI collaboration @ISOLDE/GSI

Result of RIB activities in the ^{100}Sn region so far:

- ^{108}Sn:Phys. Rev. C 72, 061305 (2005)
- ^{110}Sn: Phys. Rev. Lett. 98, 172501 (2007)
- ^{106,108}Sn: Phys. Rev. Lett. 101, 012502 (2008)
- ^{100,102,104}Cd: Phys. Rev. C 80, 054302 (2009)
- ^{106,108}In multiplets: Eur. Phys. J. A (2010)

Sn: the low lying energy levels

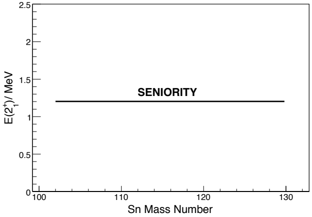


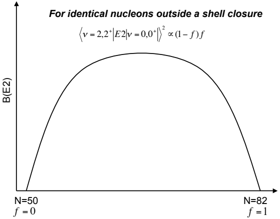
Seniority: a broken-pair model

Seniority in j^n: $S_J = \frac{1}{2}\sum(-1)^{j-m}a^+_{jm}a^+_{j,-m}$ creates a pair of nucleons coupled to $J = 0$.

Quasi-spin operators form an SU(2) Lie group. Simple relations follow:

- Constant 2^+ energy
- Simple B(E2) trend as function of shell filling





Generalized Seniority: an overview

With the inclusion of several orbits, as for the Sn-chain, the group structure is *destroyed*:

$$\mathcal{S}^{+} = \sum_{j} \alpha_j S_j^{+} \tag{1}$$

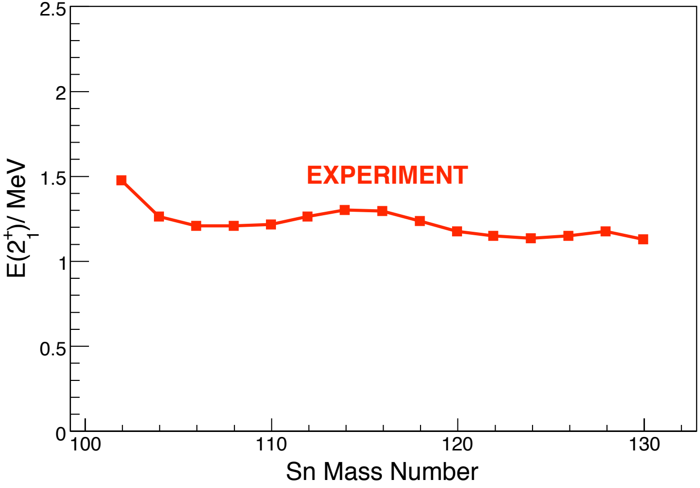
Some features of the seniority scheme are retained:

- $E(2^+) - E(0^+)$ difference
- Binding- and separation energies

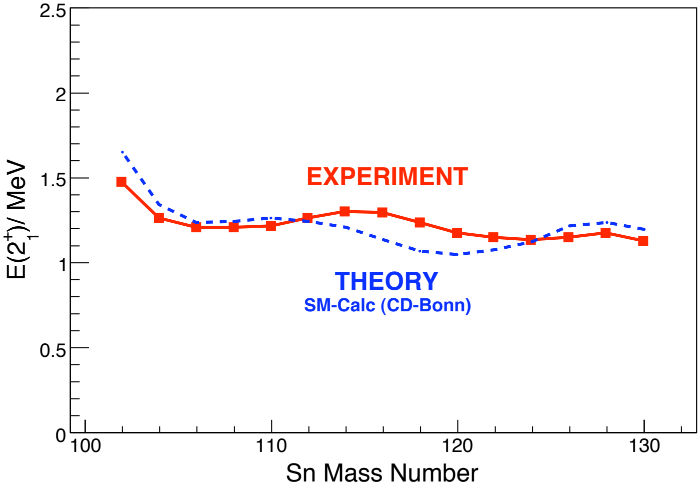
But not the general expressions for matrix elements of tensor operators.

Generalized seniority in the Sn isotopes

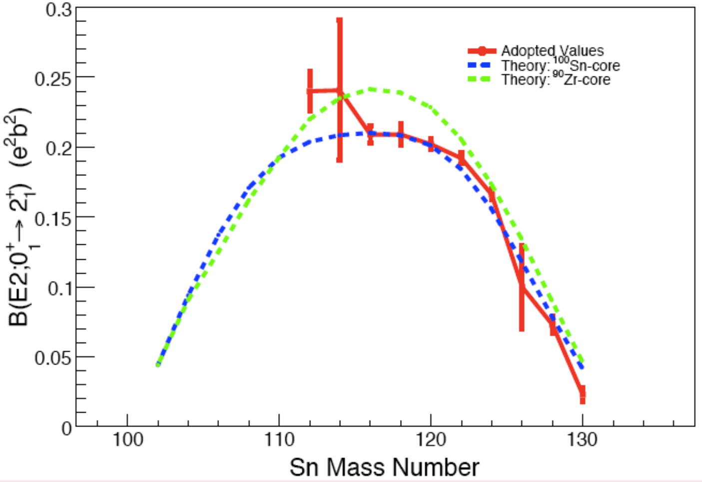
Almost constant $E(2^+) - E(0^+)$ accross the chain



Generalized seniority in the Sn isotopes

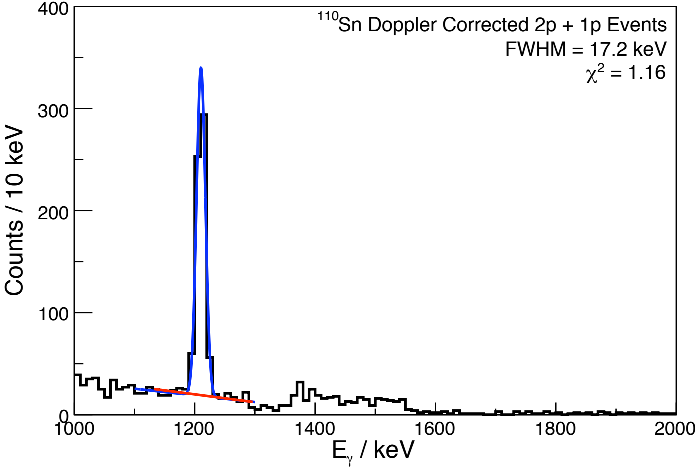


Prior experimental knowledge (2006-2007)



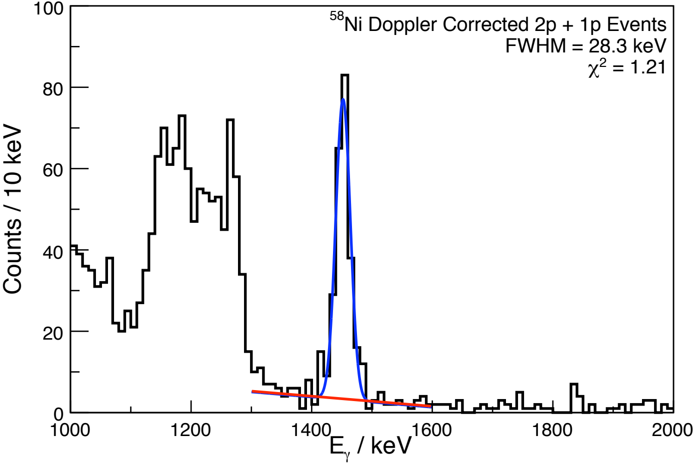
γ-ray energy spectrum

Prompt + Doppler corrected ^{110}**Sn projectile**



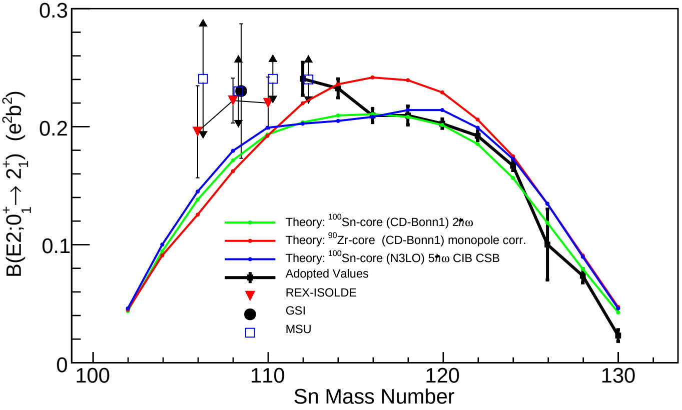
γ-ray energy spectrum

Prompt + Doppler corrected ^{58}**Ni target**



Survey of our experiments
The neutron-deficient Sn isotopes

Measured 3 $B(E2)$ values



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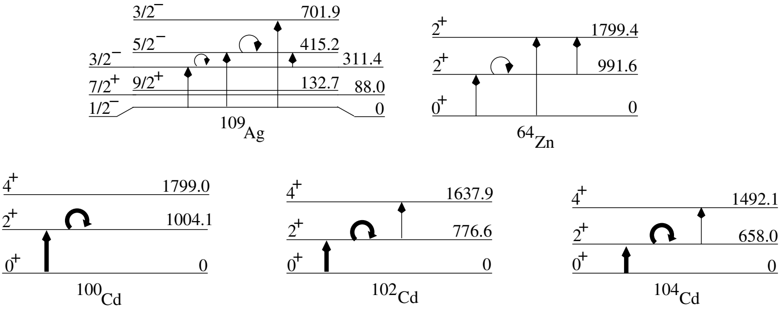
Cd: Low lying energy levels

More complex target structure



Cd - isotopes: slightly different analysis

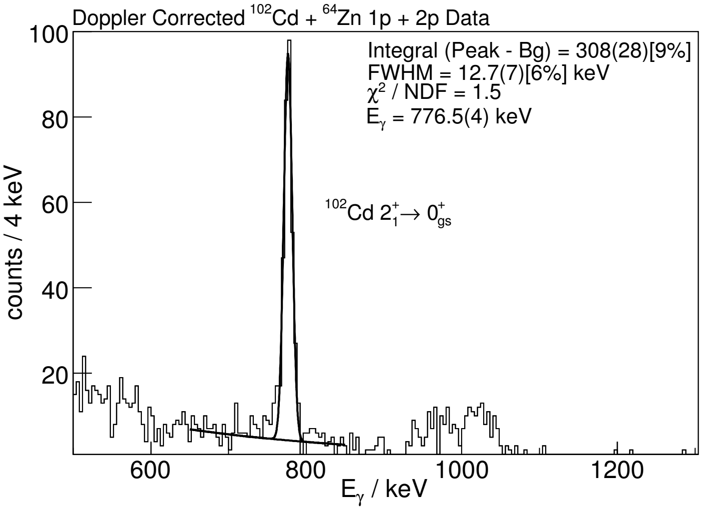
1. For the Sn isotopes $Q(2^+) = 0$ was assumed based on measurements in stable Sn. The same does not hold for the light Cd isotopes. This due to the two proton-holes in the ^{100}Sn core. The non-zero Q has an impact on the measured cross section:

$$\sigma_{E2} = \sigma_R \left[\kappa_1(\theta_{c.m.}, \xi) B(E2)(1 + \kappa_2(\theta_{c.m.}, \xi) Q(2_1^+))\right] \quad (2)$$

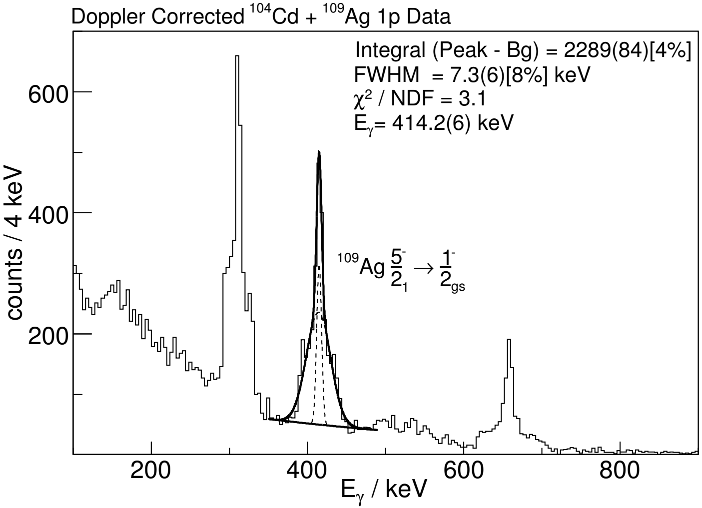
Analysis requirement: Minimum two measurements and simulation to clarify the resulting Doppler correction

- ^{109}Ag -target
- The kinematical branches of the scattered projectile and target nuclei overlap.
- ^{64}Zn -target (two angular regions measured)

Experimental γ-ray energy spectrum ^{102}Cd+^{64}Zn



Experimental γ-ray energy spectrum ^{104}Cd+^{109}Ag



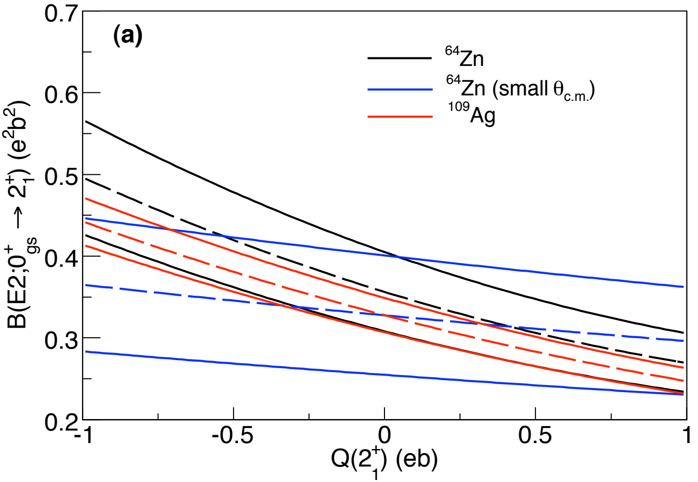
Likelihood approach of combining all experimental measurements

The projectile matrix elements $\langle 0^+_{gs}||E2||2^+_1\rangle$ and $\langle 2^+_1||E2||2^+_1\rangle$, are extracted using a maximum likelihood approach.
The likelihood, $\mathcal{L}$, is a function of the nuclear parameters $B(E2)$ and $Q(2^+_1)$. It is defined as a product of probability distributions, P_k, one for each measurement.

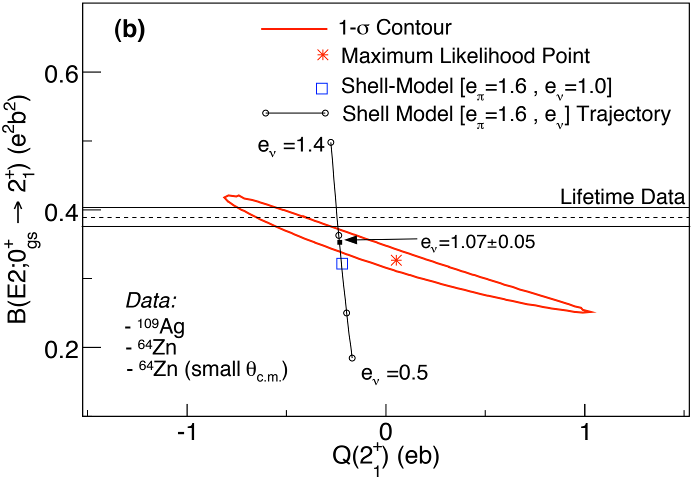
$$\mathcal{L}(B,Q) = \prod_{k\in[Zn,Ag,\tau]} P_k(B,Q) \quad (3)$$

In the numerical analysis, P_k is approximated by a Gaussian probability distribution along the gradient of the contour curve of the k-th measurement. The final $B(E2)$ and $Q(2^+_1)$ values, $\hat{B}$ and $\hat{Q}$, maximize the normalized likelihood function.

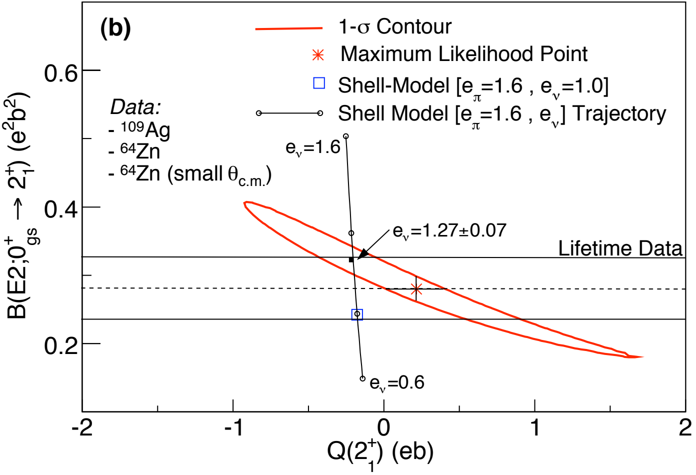
Probabilty contours: ^{104}Cd



Likelihood surface: ^{104}Cd



Likelihood surface: ^{104}Cd



Result: $B(E2)$ and $Q(2_1^+)$ values in ^{100,102,104}Cd

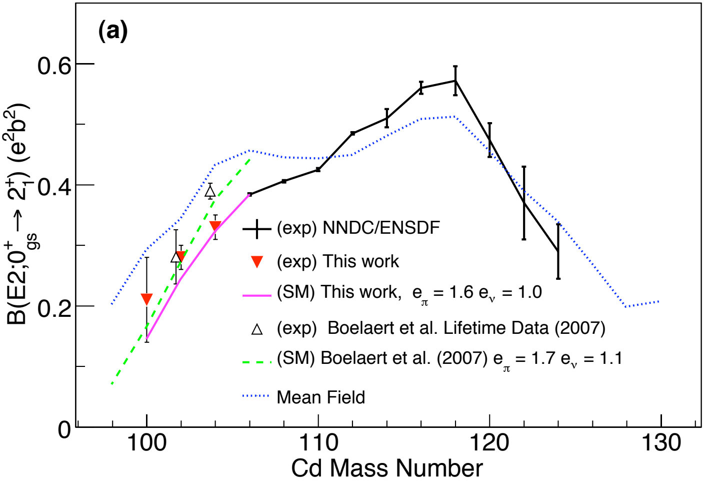
	$\tau(2_1^+)$ Included	$B(E2; 0_{gs}^+ \rightarrow 2_1^+)$ / e^2b^2	$Q(2_1^+)$ / eb
^{104}Cd	No	$0.33 \pm 0.01 \pm 0.02$	$0.06 \pm 0.10 \pm 0.11$
	Yes	0.39 ± 0.01	-0.52 ± 0.19
^{102}Cd	No	$0.28 \pm 0.02 \pm 0.02$	$0.22 \pm 0.11 \pm 0.15$
	Yes	0.28 ± 0.04	0.22 ± 0.43
^{100}Cd	No	≤ 0.28	0.0[1]

[1] Fixed in the analysis in order to extract the corresponding $B(E2)$.

Survey of our experiments

The neutron-deficient Cd isotopes

Measured 3 $B(E2)$ values



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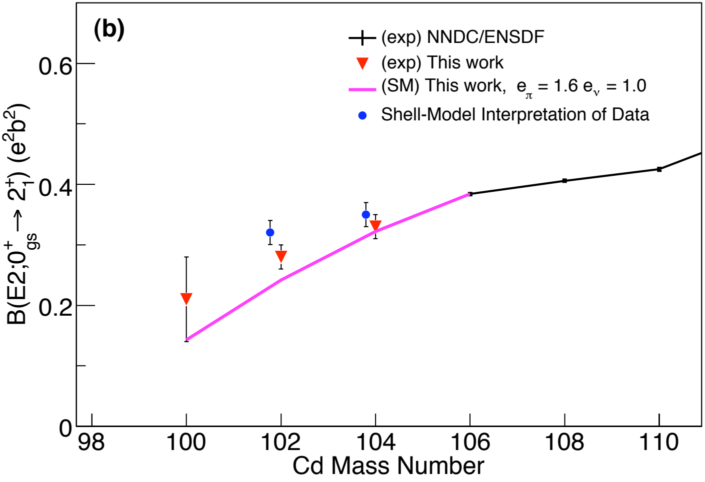
Shell-model vs experiment



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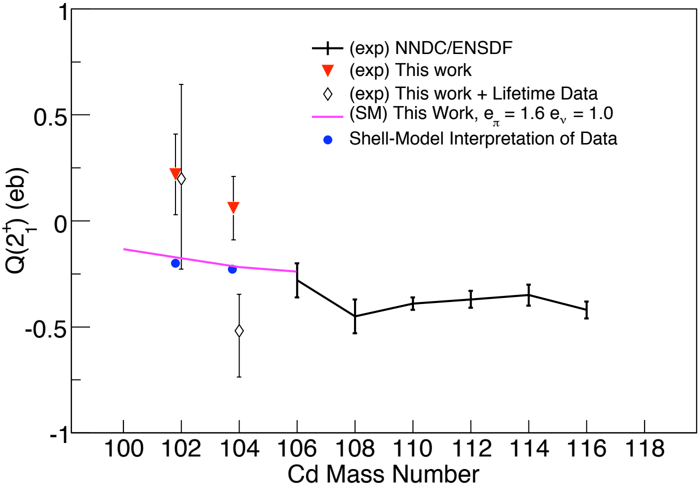
Survey of our experiments

The neutron-deficient Cd isotopes

and 2 $Q(2^+)$ values



Summary

- The $B(E2)$ values in the light even-mass Sn isotopes deviate from large scale shell-model predictions. This indicates the need for further core-polarization terms in the effective interaction.
- The $B(E2)$ and $Q(2_1^+)$ values in the light Cd isotopes do not deviate conspicuously from what is expected when approaching a closed shell although an effect is present.

Yields from LISE++ and MOCADI

Accepted experiment S372 (fall 2010).
15 shifts with primary ^{124}Xe beam.

Table 1: MOCADI simulation results for various fragment settings. Energy given in MeV/u.

Fragment	^{104}Sn setting (s^{-1})	Energy	^{106}Sn setting (s^{-1})	Energy	^{100}Cd setting (s^{-1})	Energy
^{103}Sn	12	119	-	-	4	127
^{104}Sn	287	110	1	146	26	116
^{105}Sn	1731	101	260	135	1	105
^{106}Sn	1965	90	4255	125	-	-
^{107}Sn	141	76	6003	114	-	-
^{101}In	16	133	-	-	18	139
^{102}In	504	122	-	-	282	129
^{103}In	3684	114	9	146	873	118
^{98}Cd	0.03	156	-	-	-	-
^{100}Cd	394	134	-	-	725	140
^{101}Cd	4116	125	-	-	3482	130
^{102}Cd	8863	116	-	-	3182	119
^{100}Ag	6724	126	-	-	9409	131

Plan

1. Run ^{104}Sn and ^{100}Cd in fall 2010.
2. Estimate yields for isotopes on the Z=50 and N=50 lines.
3. Submit addendum to proposal if yields reasonable.