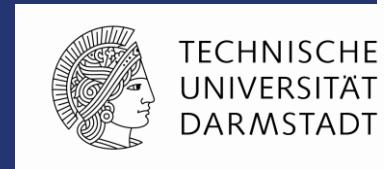


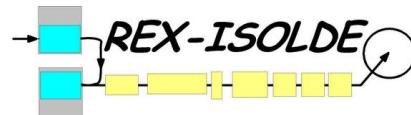
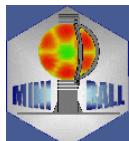
# Coulomb excitation of neutron-rich $^{134,136}\text{Sn}$ isotopes



CERN-INTC-2012-042, INTC-P-343

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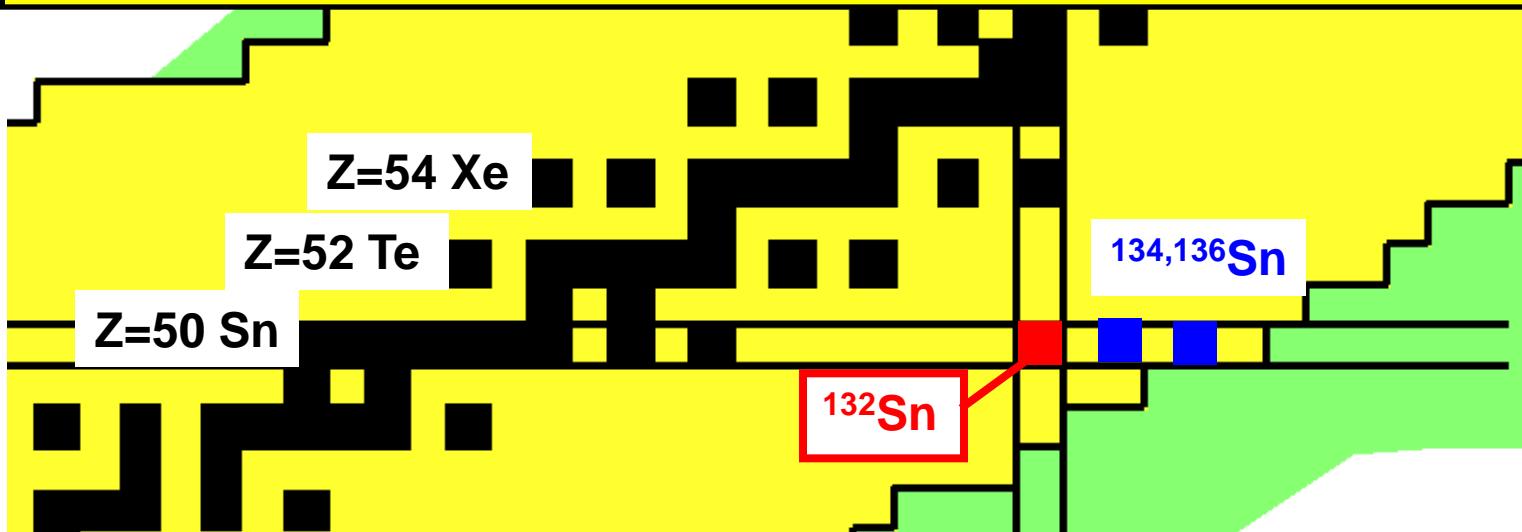


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# Region of Interest

- Doubly-magic shell closure in  $^{132}\text{Sn}$ 
  - below N=82 (nearly) perfect seniority scheme
- $^{132}\text{Sn} + 1$  or 2 pairs of neutrons (**exclusively neutron-neutron interaction**)
  - $E(2^+) = 726 \text{ keV}$  in  $^{134}\text{Sn}$
  - but  $B(E2; 0^+ \rightarrow 2^+)$  similar to  $^{130}\text{Sn}$
  - Asymmetry with respect to N=82, but different compared to  $^{136}\text{Te}$
- no excitation energy or  $B(E2)$  value known for  $^{136}\text{Sn}$



Letter of Intent: CERN-INTC-2010-045; INTC-I-111

# $^{134}\text{Sn}$ – experiment and theory



	$^{134}\text{Sn}$	
	exp.	theo.
$E(2^+)$ [keV]	726.5 [13]	774.8 [10] 733.0 [9]
$E(4^+)$ [keV]	1073.4 [13]	1116.1 [10] 1070.0 [9]
$E(6^+)$ [keV]	1247.4 [13]	1258.2 [10]
$B(E2; 0_{\text{gs}}^+ \rightarrow 2^+)$ [ $e^2\text{b}^2$ ]	0.029(5) [6]	0.031 [10] 0.029 [9] 0.034 [8]
$B(E2; 2^+ \rightarrow 4^+)$ [ $e^2\text{b}^2$ ]		0.031 [10] 0.034 [8]
$B(E2; 4^+ \rightarrow 6^+)$ [ $e^2\text{b}^2$ ]	0.0182(35) [7]	0.017 [10] 0.017 [8]

**Shell model using**

**(a) empirical interaction [9]**

**(b) realistic interaction  
derived from  
nucleon-nucleon-potential  
[8,10]**

**... both reproduce  
experimental data  
equally well!!!**

# $^{136}\text{Sn}$ – theoretical predictions



	$^{136}\text{Sn}$ theo.
$E(2^+)$ [keV]	733.9 [10] 578.0 [9] 639.0 [12]
$E(4^+)$ [keV]	1161.4 [10] 884.0 [9]
$E(6^+)$ [keV]	1377.0 [10]
$B(E2; 0_{\text{gs}}^+ \rightarrow 2^+) [e^2 b^2]$	0.062 [10] 0.045 [9]
$B(E2; 2^+ \rightarrow 4^+) [e^2 b^2]$	0.043 [10]
$B(E2; 4^+ \rightarrow 6^+) [e^2 b^2]$	0.007 [10]

Shell model using

(a) empirical interaction [9]

(b) realistic interaction [10]

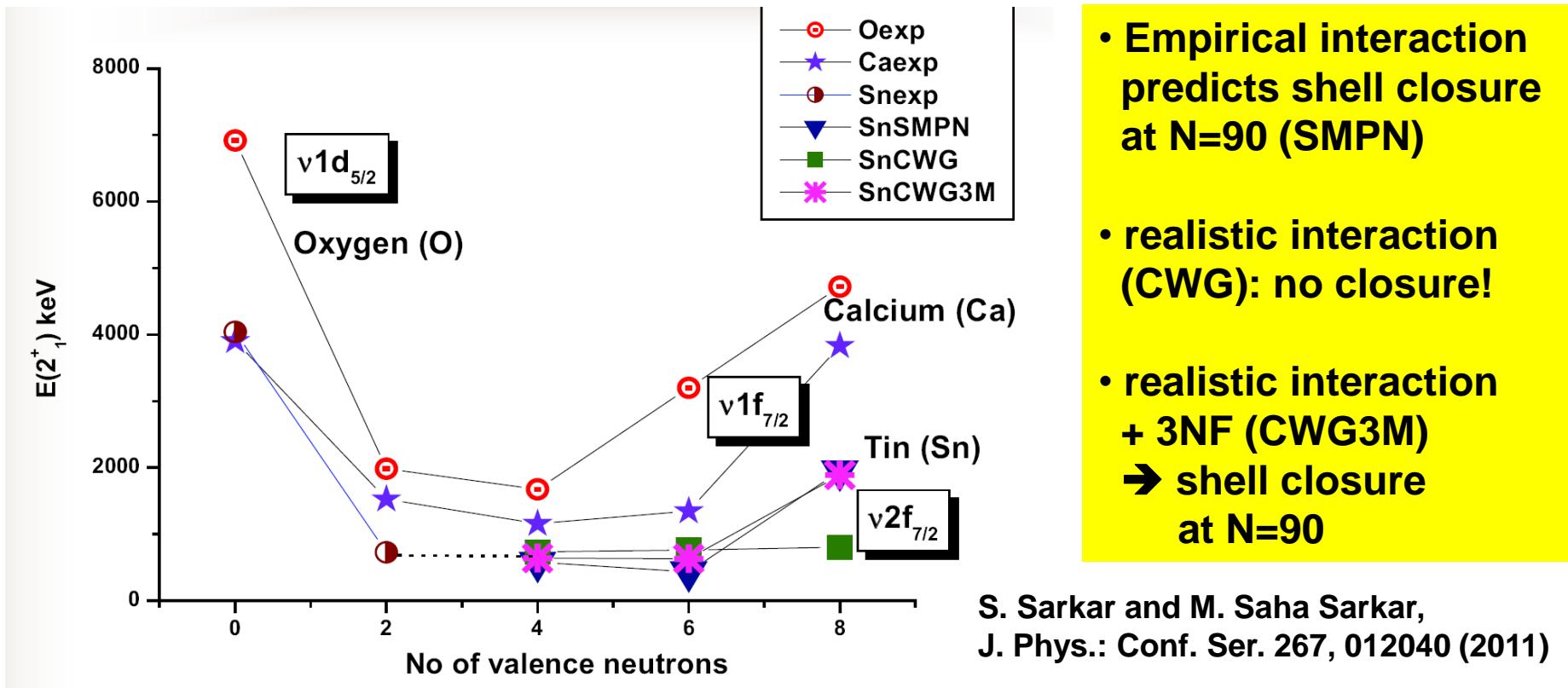
(c) realistic interaction + 3NF [12]

Predictions differ largely

- excitation energies by 150 keV
- $B(E2)$  values by 40%

- neutrons fill  $\nu f_{7/2}$  orbital
- neutron-neutron part in the interactions can be tested exclusively by comparison with experiment

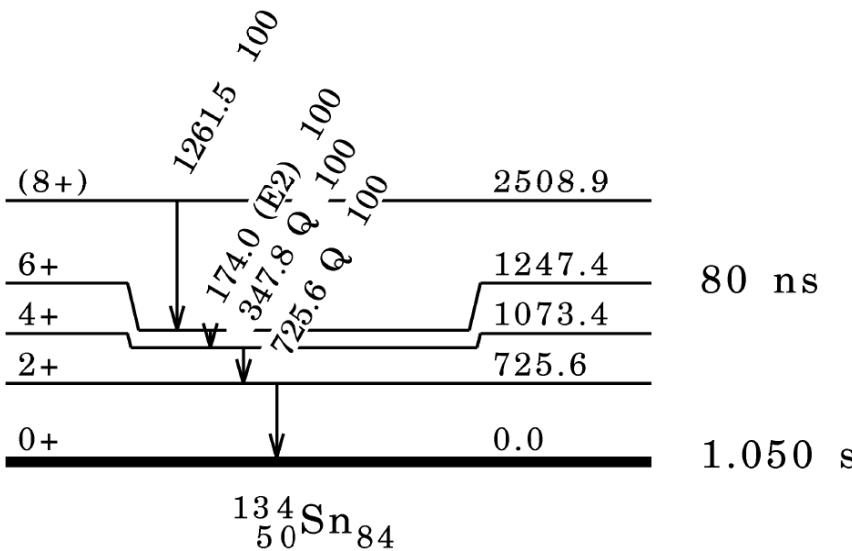
# 3NFs and shell closures



Very similar situation (again  $vf_{7/2}$  neutrons) in the Ca isotopic chain:  
Realistic interaction reproduces the N=28 shell closure in  $^{48}\text{Ca}$  only if  
3NF is added

J. D. Holt et al., J. Phys. G: Nucl. Part. Phys. 39, 085111 (2012)

# Physics aims



## Multiple Coulomb excitation

Observed yields depend on only  
**four E2 matrix elements** (as  $6^+$   
state is isomeric):

- 2 transitional MEs
- 2 diagonal MEs

No additional input needed  
for analysis!

## Physics aims

- transitional quadrupole MEs →  $B(E2)$  values
- diagonal E2 MEs → quadrupole moments  $Q_2$

The excitation energies in  $^{136,138}\text{Sn}$  will be (hopefully) measured in Nov 2012 at RIKEN observing the decay of the  $6^+$  isomers

Ergo: the envisaged results of the two experiments are complementary

# Experimental details



Same set-up as for INTC-342: MINIBALL + modified T-REX configuration

- Large angular range (CMS):  $25^\circ$ - $170^\circ$   
→ different sensitivities on single/multiple excitation and reorientation
- Sensitivity to diagonal ME up to 40% (ME =  $\pm 0.5$  eb)
- Safe energy: 4.4 MeV/u ( $^{206}\text{Pb}$  target)
- Molecular beam  $\text{Sn}^{34}\text{S}^+$

	$T_{1/2}$ [ s ]	Yield [ / $\mu\text{C}$ ]	Int [ /s ]
$^{134}\text{Sn}$	1.06	$10^6$	$10^5$
$^{136}\text{Sn}$	0.25	$2 \cdot 10^4$	$10^3$

The beam composition for  $^{136}\text{Sn}$   
is known from run of IS441  
... Luis Fraile has just to find the numbers

Losses due to decay  
similar to  $^{128}\text{Cd}$  (IS477)

# Rate estimate / beam request (II)



Doubly-differential cross section to be analysed

→ split data set into 5-12 angular bins

$^{134}\text{Sn}$  (2 days of beam time)

750/13 particle- $\gamma$ -coincidences/h for  $2^+/4^+$  state

→ < 2% statistical error per angular bin for  $2^+$  state  
(previous value has 17% error)

→ < 10% statistical error per angular bin for  $4^+$  state

$^{136}\text{Sn}$  (8 days of beam time)

16/0.3 particle- $\gamma$ -coincidences/h for  $2^+/4^+$  state

→ < 5% statistical error per angular bin for  $2^+$  state  
(predictions from theory differ by 40%)

→ < 20% statistical error for  $4^+$  state

We request 30 shifts (10 days) of beam time