

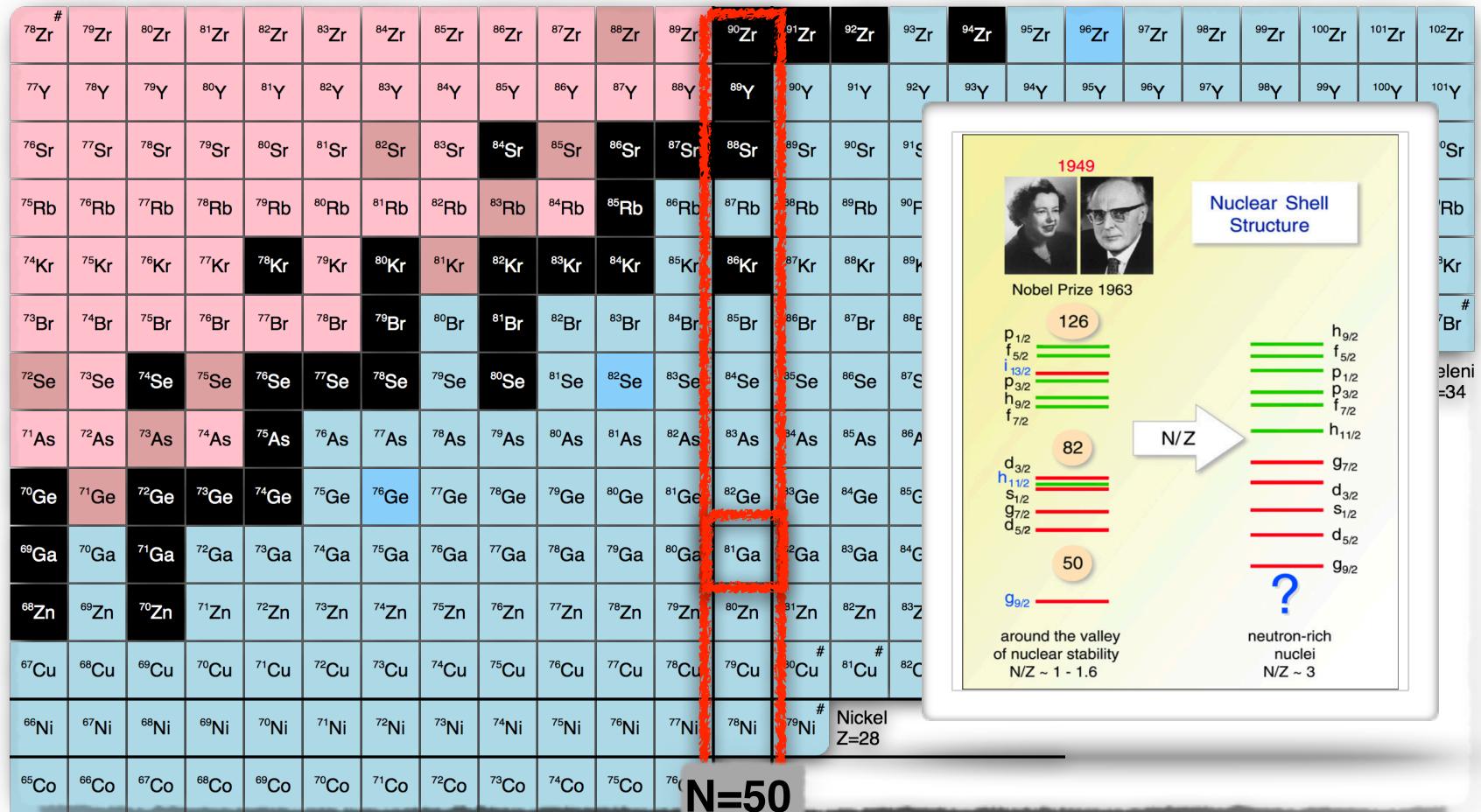
Resolving the low-lying structure of ^{81}Ga using the Coulomb excitation technique

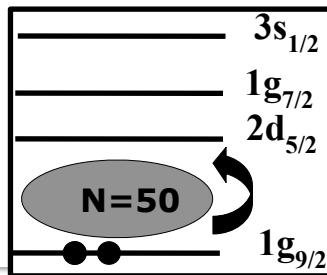
Spokesperson: *E. Sahin, **A. Gottardo, ***K. Hadyn'ska-Klejek, **G. de Angelis

*University of Oslo, Oslo, Norway

**INFN- Laboratori Nazionali di Legnaro, LNL, Padova, Italy

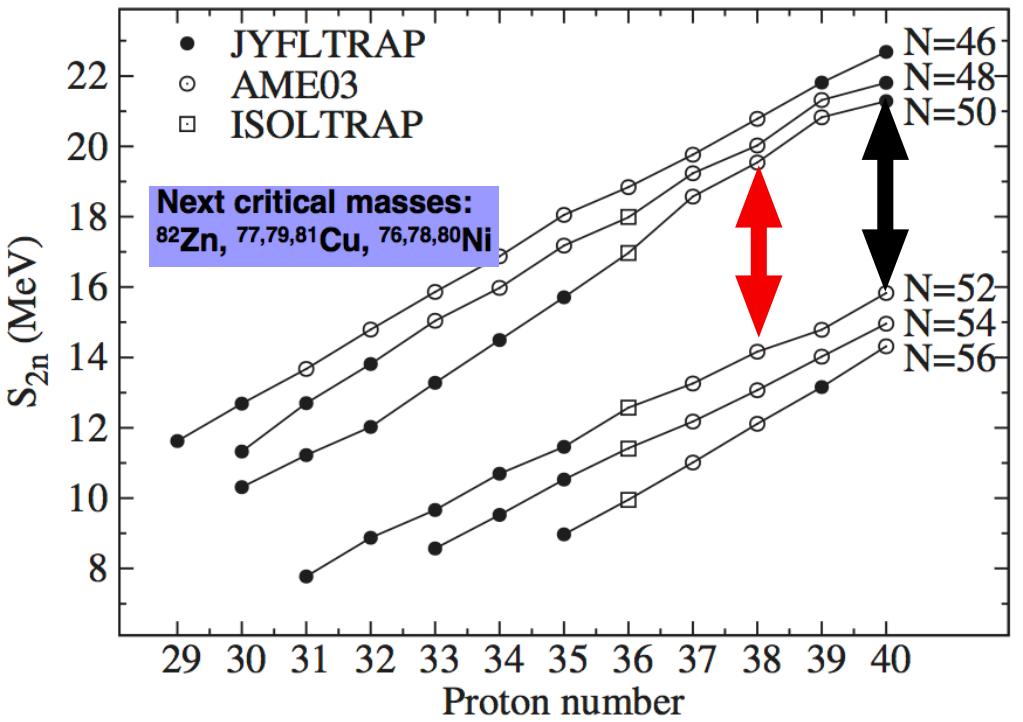
***University of Surrey, Guildford, United Kingdom





Evolution of the N=50 shell gap

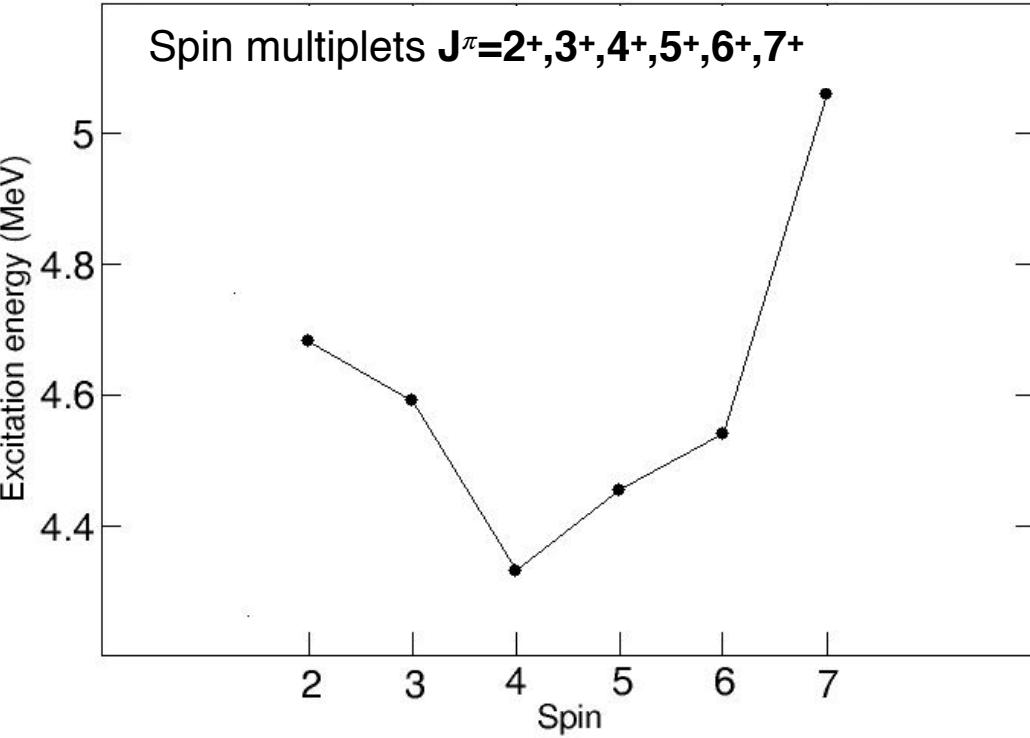
MASS MEASUREMENTS



PARTICLE-HOLE EXCITATIONS

$$\nu g_{9/2}^{-1} \nu d_{5/2}^{+1}$$

$$|\frac{5}{2} - \frac{9}{2}| \leq J \leq \frac{5}{2} + \frac{9}{2}$$

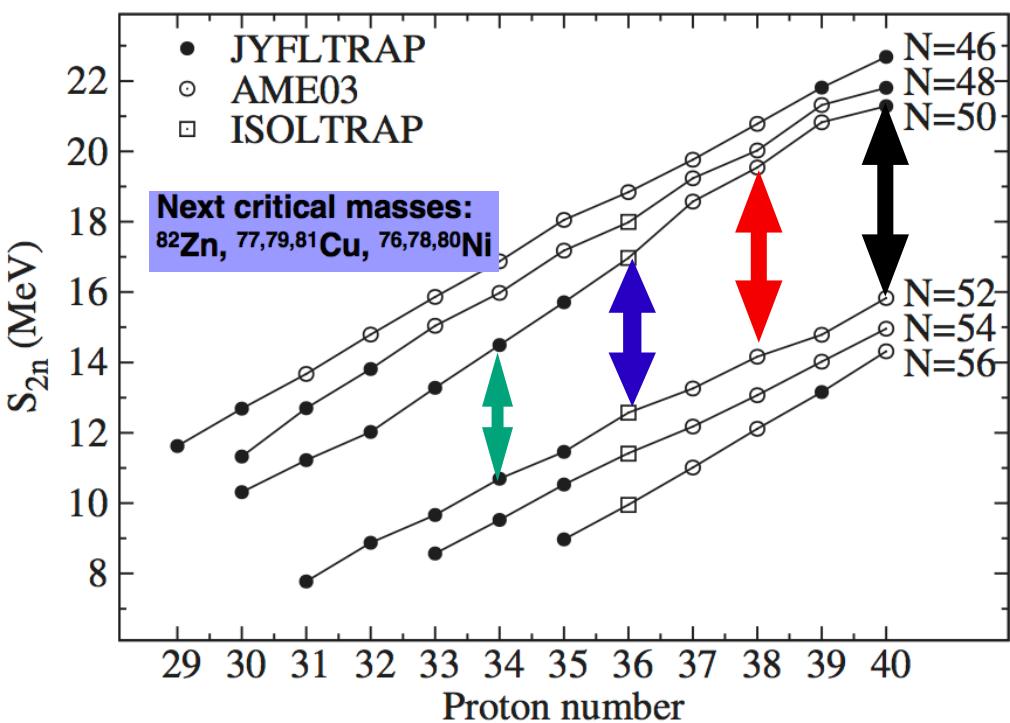


^{90}Zr ($Z=40$)

^{88}Sr ($Z=38$)

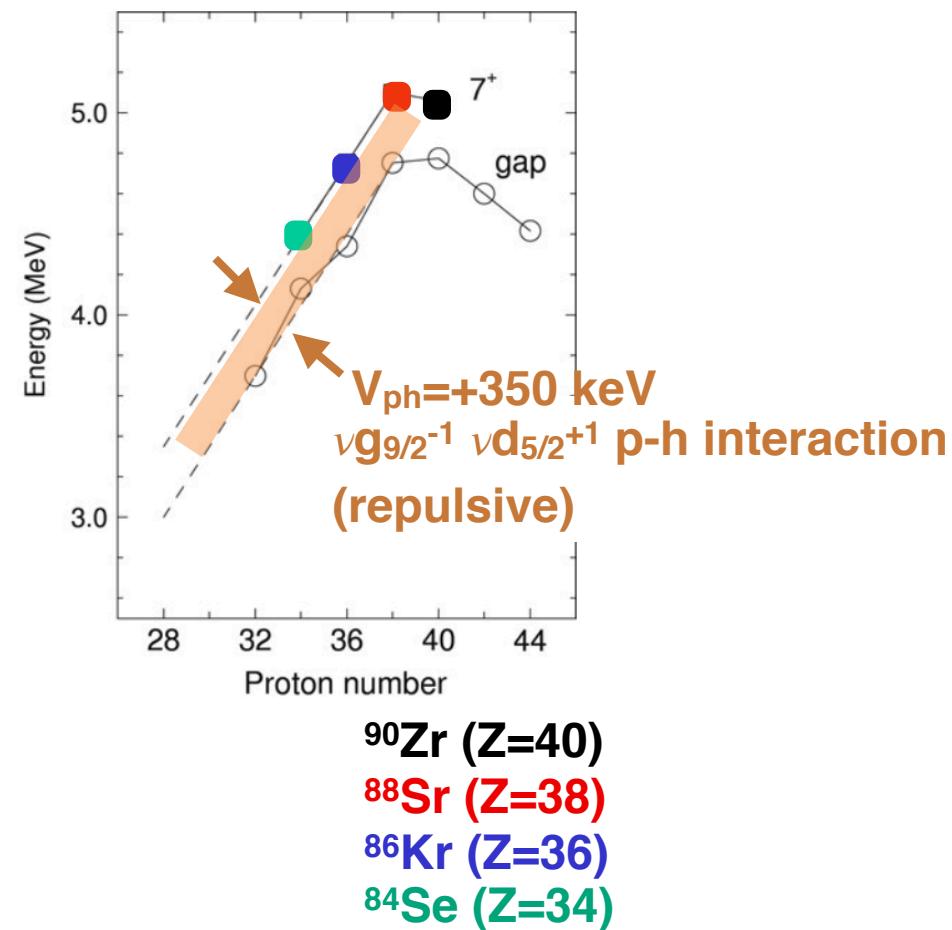
Evolution of the N=50 shell gap

MASS MEASUREMENTS



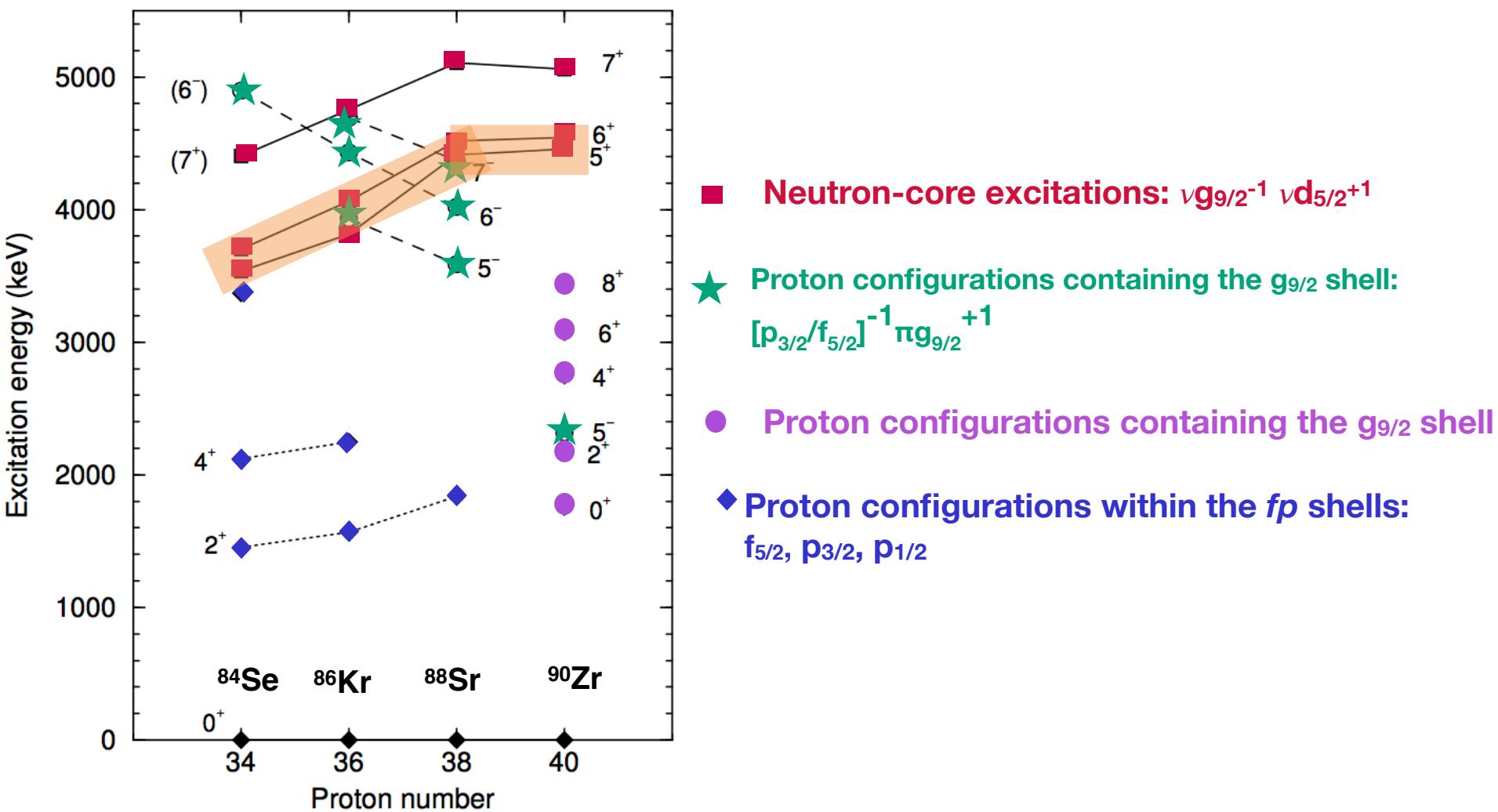
PARTICLE-HOLE EXCITATIONS

7⁺ states from γ -ray spectroscopy



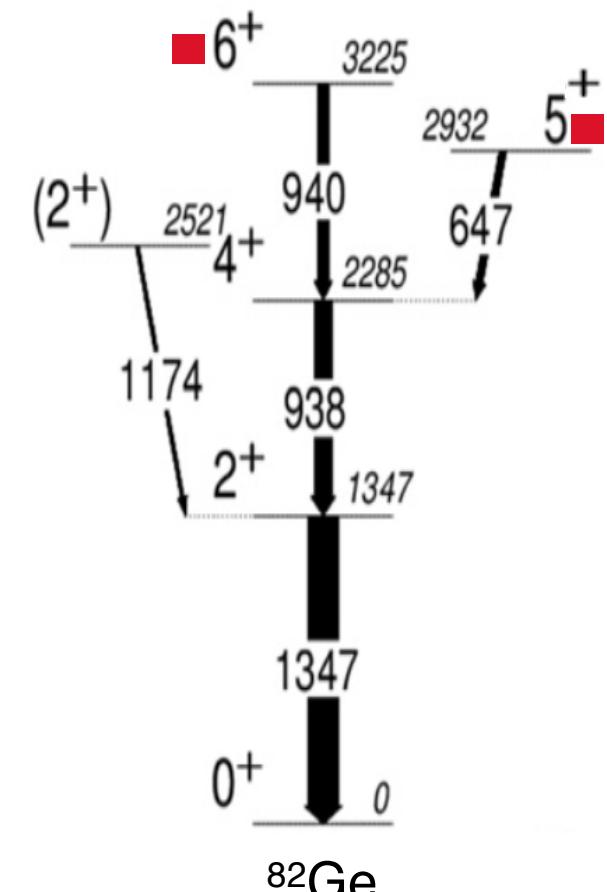
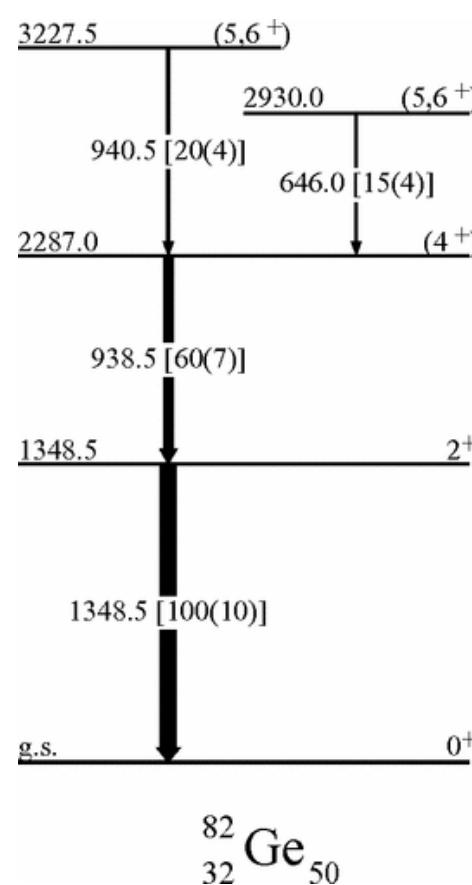
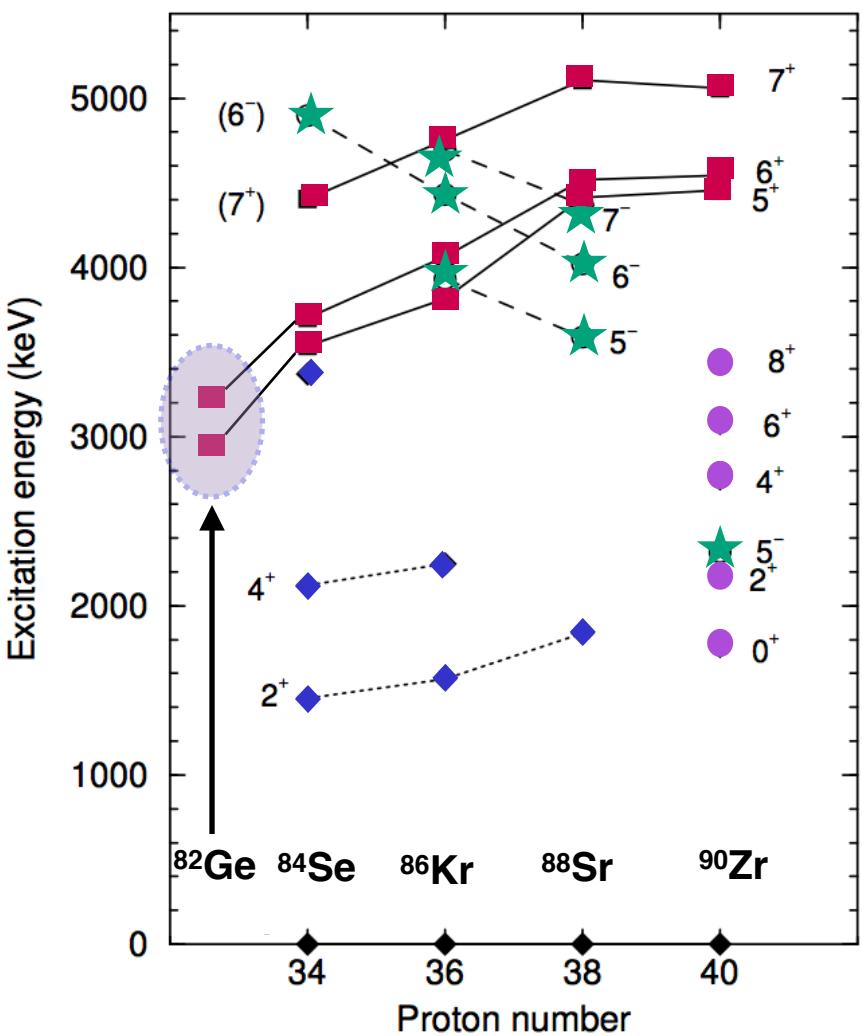
PARTICLE-HOLE EXCITATIONS: EVEN-A N=50 Isotones

5⁺ and 6⁺ states from γ -ray spectroscopy



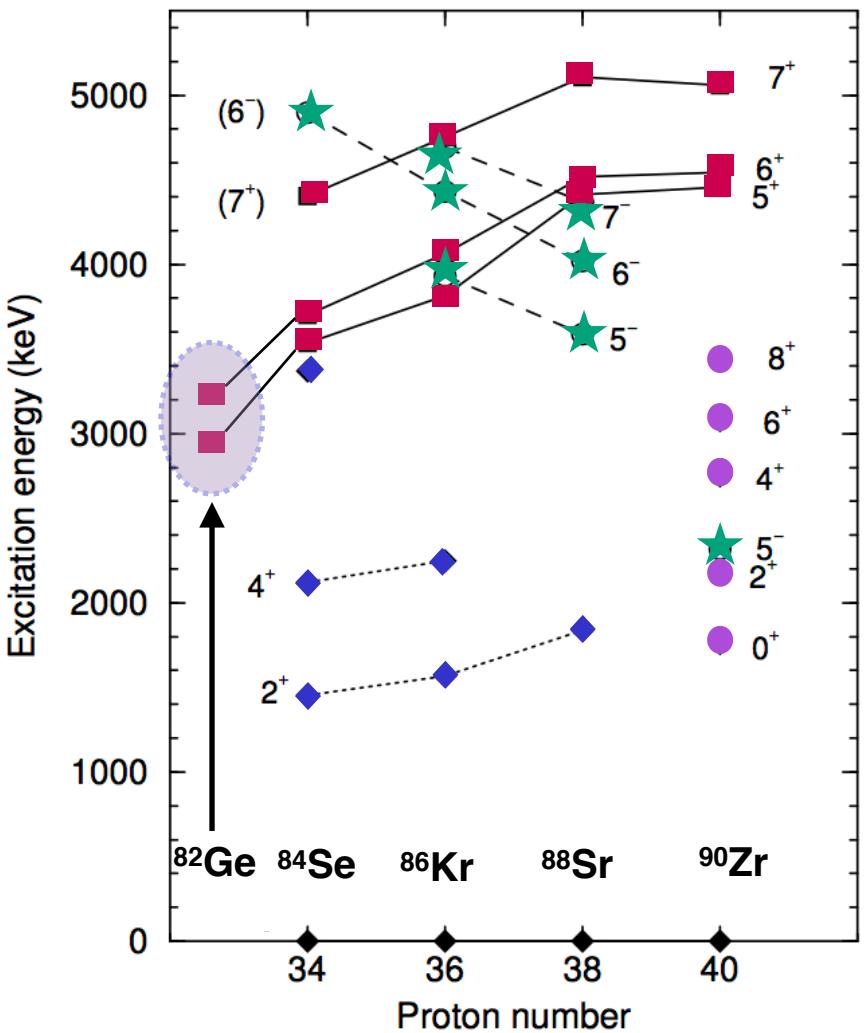
PARTICLE-HOLE EXCITATIONS: EVEN-A N=50 Isotones

Multi-nucleon transfer reaction with thin and thick targets at LNL, Italy

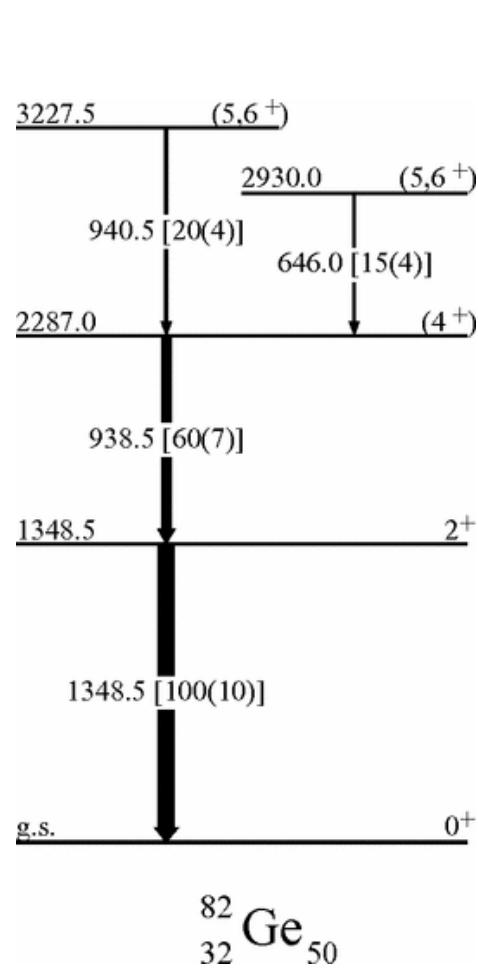


Spin assignments from angular distributions

PARTICLE-HOLE EXCITATIONS: EVEN-A N=50 Isotones

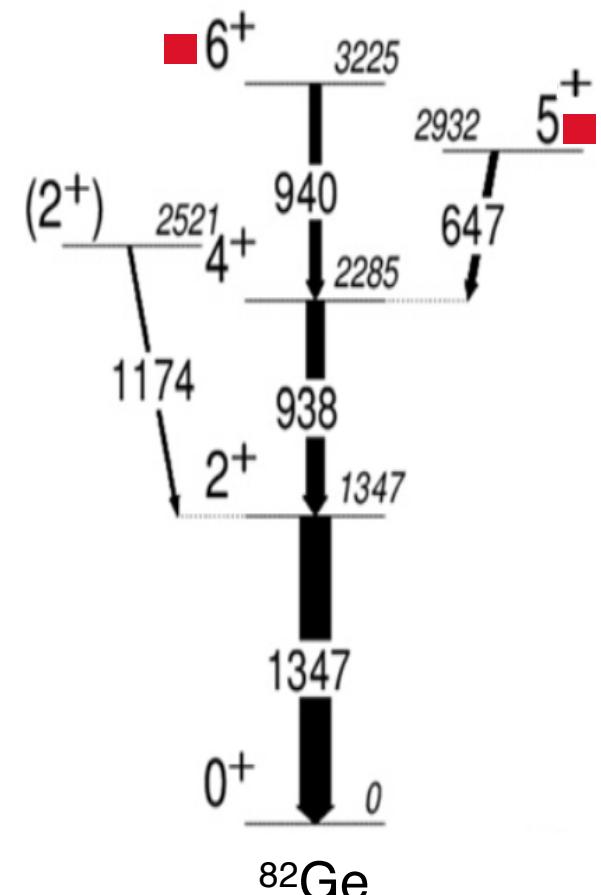


A. Prévost, et al., Eur Phys. J. A 22 (2004) 391.



T. Rząca-Urban et al.,
Phys. Rev. C 76, 027302 (2007)

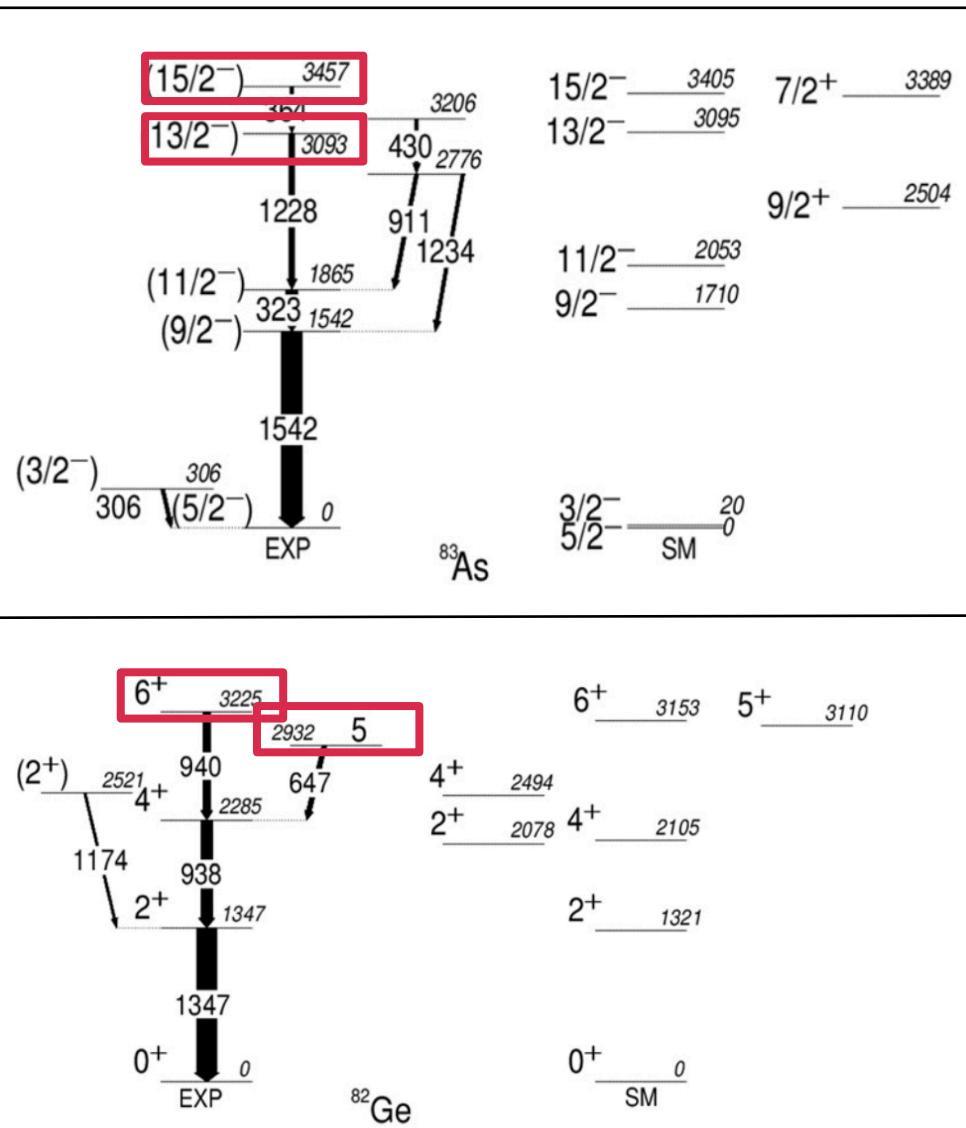
Multi-nucleon transfer reaction with thin and thick targets at LNL, Italy



Spin assignments from angular distributions

ES et al., Nucl. Phys. A 893, 1-12 (2012)

Equivalent of $5^+, 6^+$ states in ^{82}Ge
is found to be $13/2^-, 15/2^-$ in ^{83}As



SM Calculations:

A.F. Lisetskiy, B.A. Brown, M. Horoi, H. Grawe,
Phys. Rev. C 70 (2004) 044314.

Interaction: JJ4B + SDI

Model spaces: pfg9+sdg

Inert Core nucleus: ^{56}Ni

Tensor interactions are included

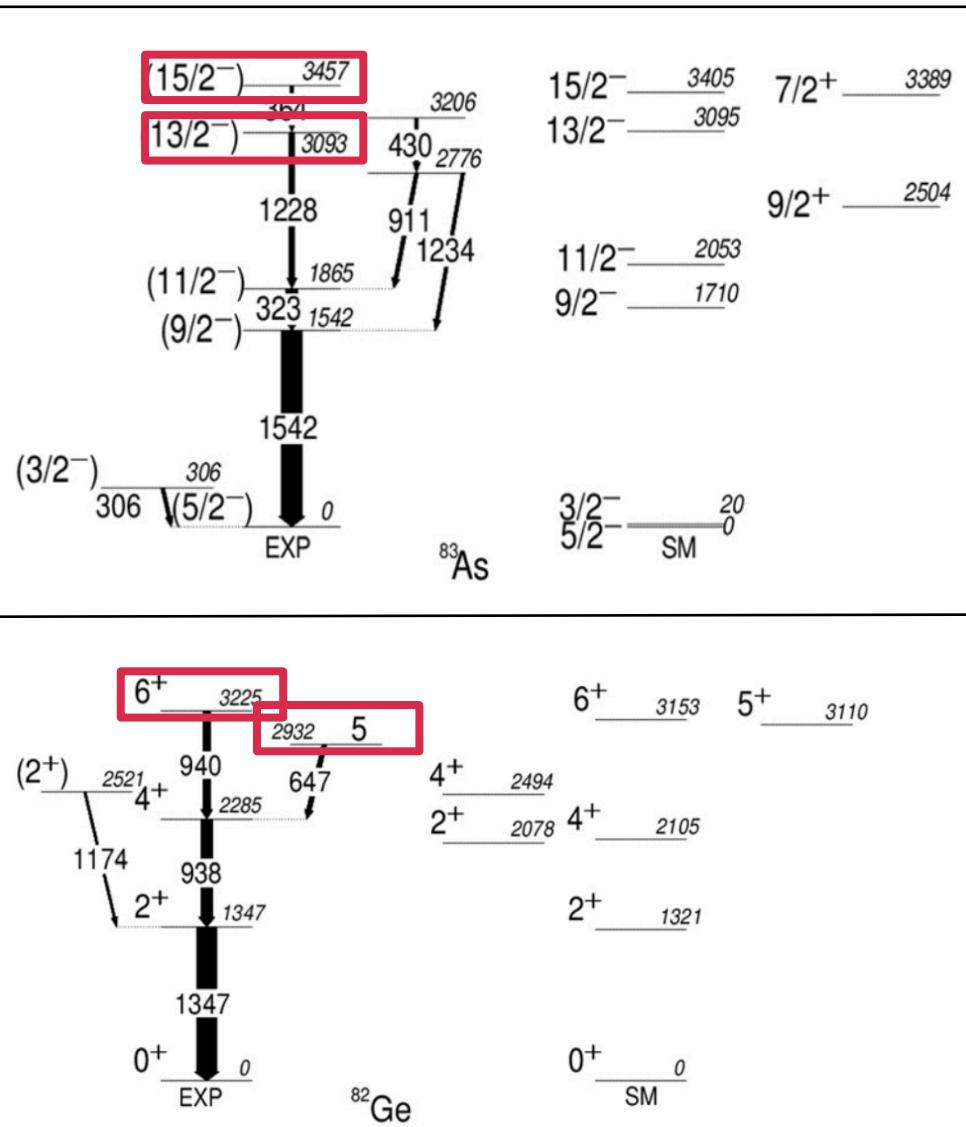
The SPEs relative to the ^{56}Ni core have been derived
from the SPEs with respect to the doubly-magic ^{78}Ni
core.



Model Space	Single-Particle Energy			
	$E(1f_{5/2})$	$E(2p_{3/2})$	$E(2p_{1/2})$	$E(1g_{9/2})$
pfg	-9.28590	-9.65660	-8.26950	-5.89440
sdg	$E(2d_{5/2})$ -1.19440	$E(3s_{1/2})$ -0.16800	$E(1g_{7/2})$ 0.2700	

$$E(\nu d_{5/2} - \nu g_{9/2}) = \text{parameter}$$

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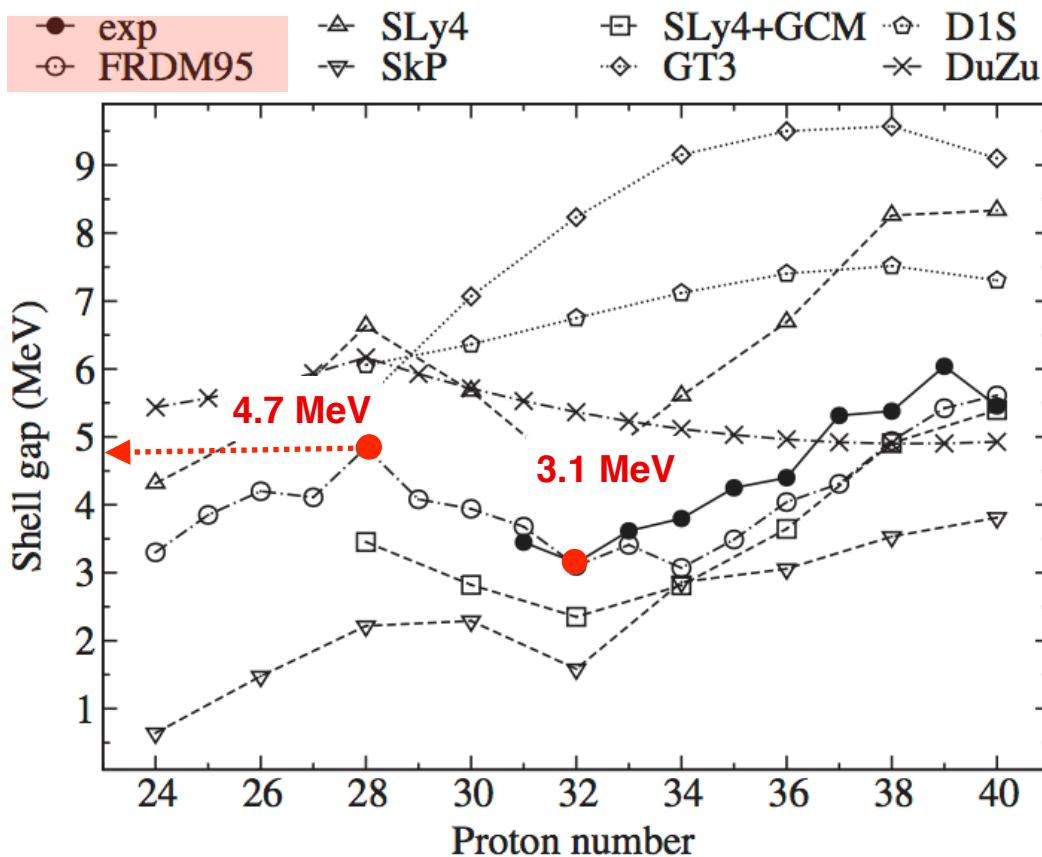
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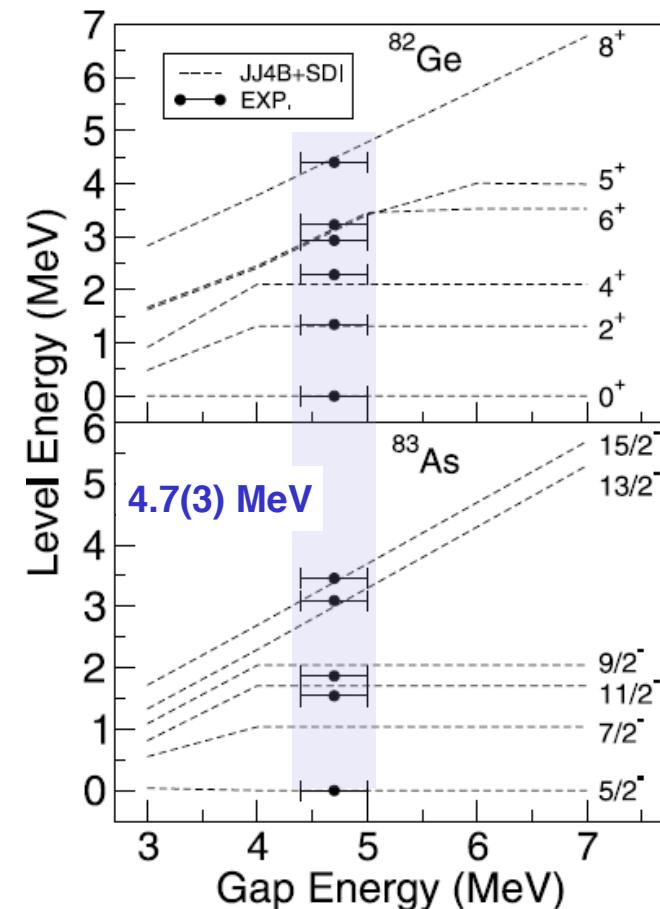
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$$E(\nu d_{5/2} - \nu g_{9/2}) = 4.7(3) \text{ MeV}$$

**Extrapolated Gap Value at Z=28 from
mass difference:
4.7 MeV**



**Gap Value at Z=28 from spectroscopy:
4.7(3) MeV**



Gap Value at Z=32(⁸²Ge)

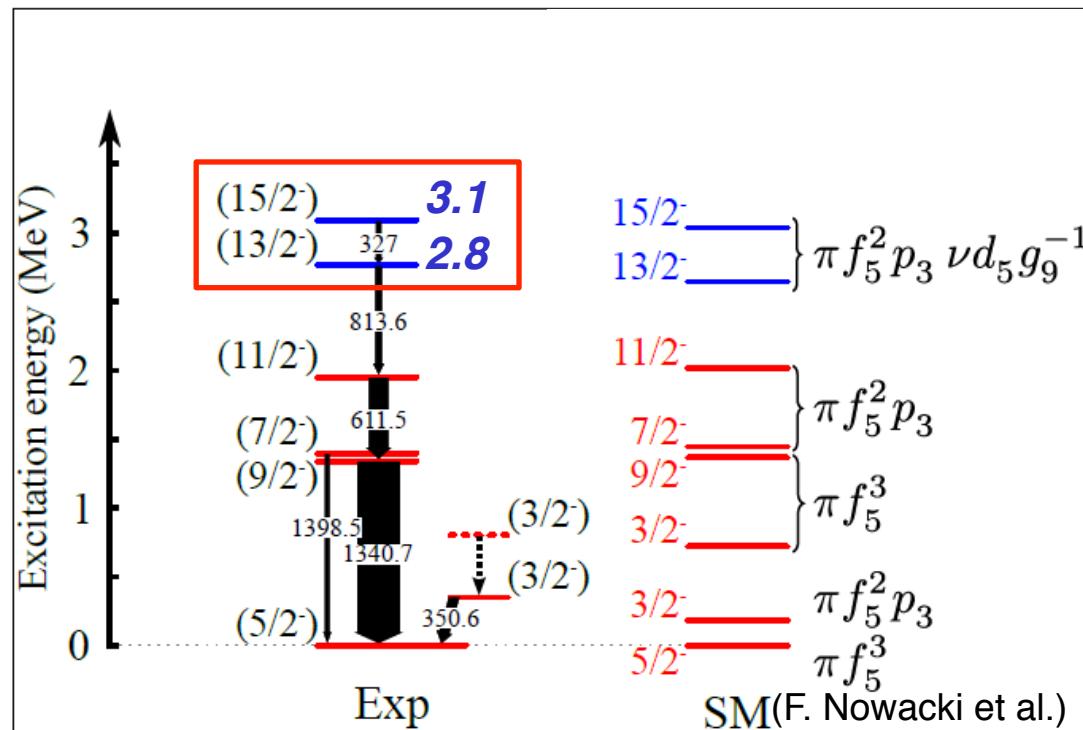
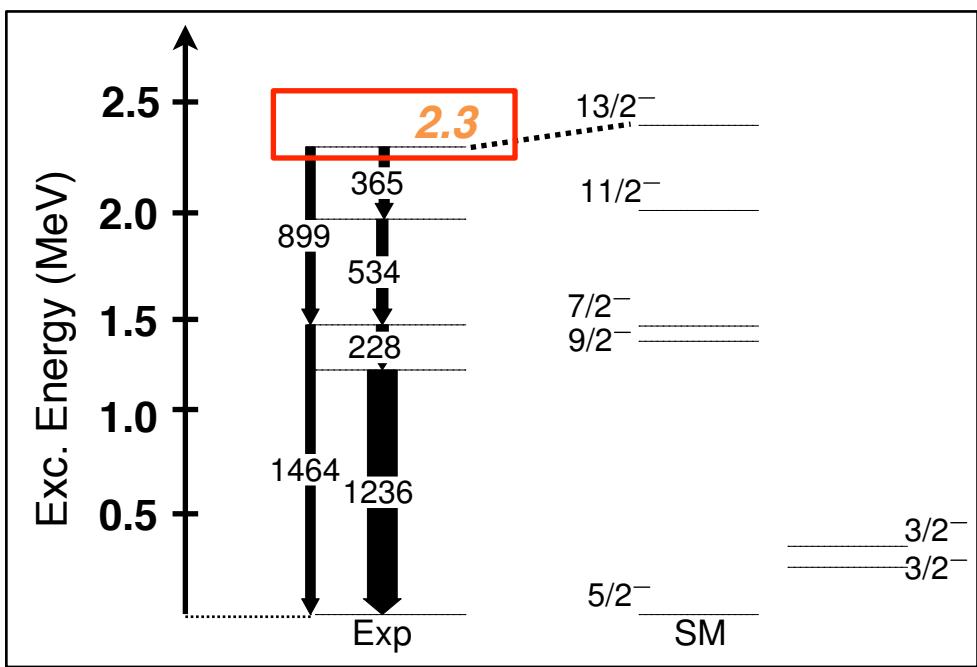
$$E(vd_{5/2} - vg_{9/2}) - V_{\text{monopole}} = 4.7 - 1.1 = 3.6(3) \text{ MeV}$$

^{81}Ga : the most exotic odd-A N=50 isotope accessible to n-p excitations

p-h excitation across
the neutron gap

1

2



Multi-nucleon transfer reaction at LNL, Italy
 $^{82}\text{Se} + ^{238}\text{U}$ E(^{82}Se)=515 MeV

CLARA γ array coupled to
 PRISMA magnetic spectrometer
 $\Theta_{\text{PRISMA}} = \Theta_{\text{Grazing}} = 64^\circ$

ES et al., Nucl. Phys. A 893, 1-12 (2012)

Fusion-fission reaction at GANIL, France
 $^{238}\text{U} + \text{Be}$ E(^{238}U)=6 MeV/nuc

AGATA γ array coupled to
 VAMOS magnetic spectrometer
 $\Theta_{\text{VAMOS}} = 28^\circ$

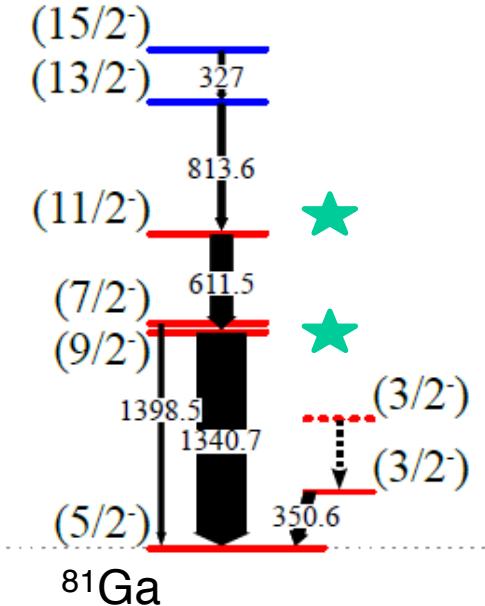
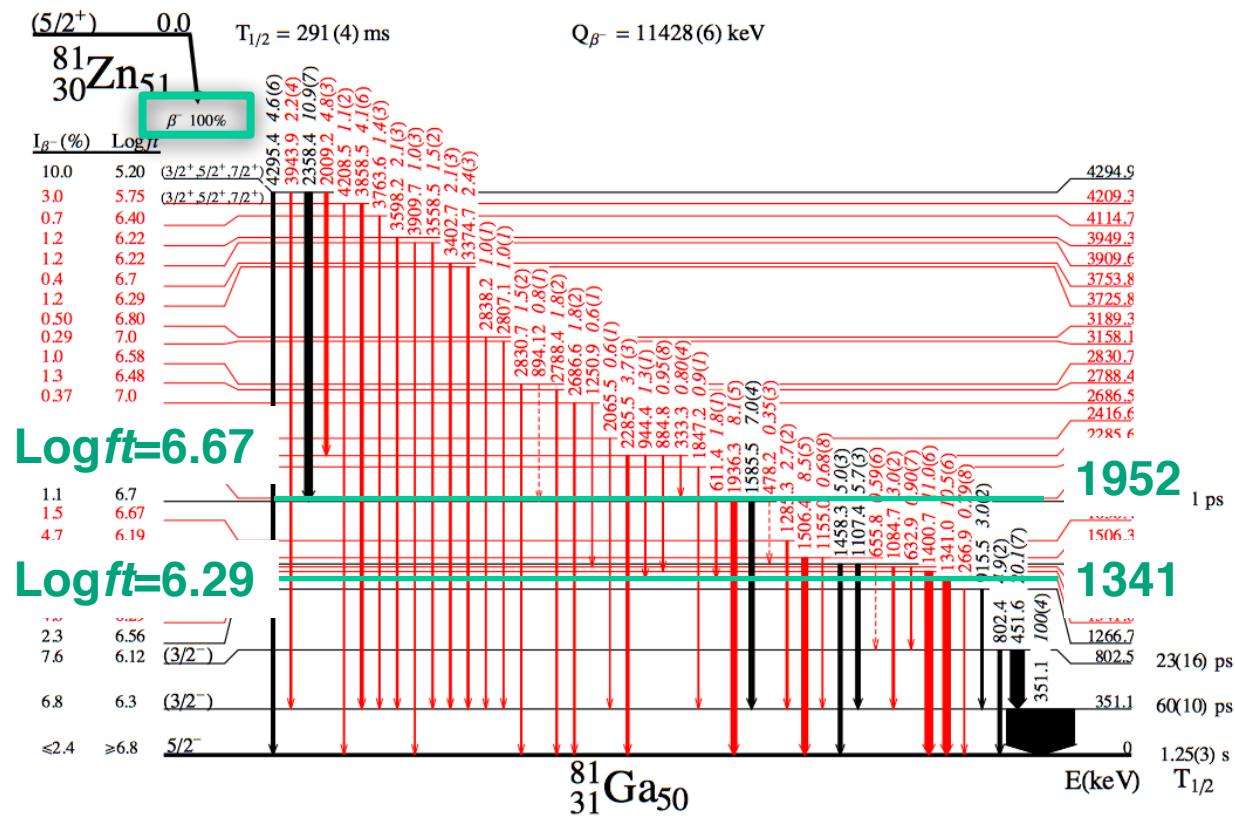
J. Dudouet, Private communication

Study of β -decay chain of ^{81}Zn at ISOLDE

States at 1952 and 1341 keV are populated via first forbidden transition in the beta decay study ($\log ft=6.67$ and 6.29, respectively)

Is not compatible with the spin-parity assignment of $9/2^-$ and $11/2^-$ at GANIL

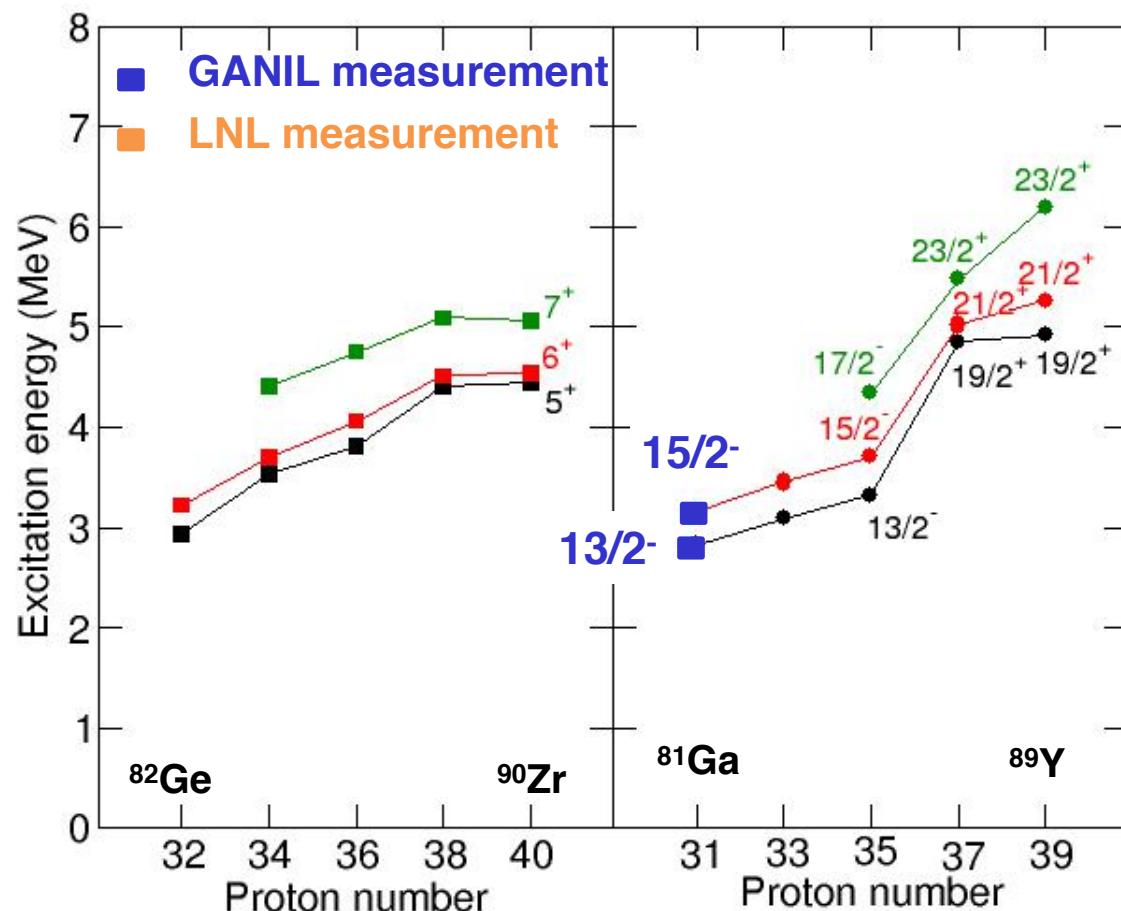
3



Identification of the ^{81}Ga level scheme in this experiment will provide information on the $1p$ - $1h$ states ($13/2^-$ and/or $15/2^-$) sensitive to the N=50 gap size

Scenario 1: GANIL level scheme is proven

The size of the N=50 gap is not drastically decreased which is in line with the mass measurements of Hakala et al., pointing an increase from Z=31.



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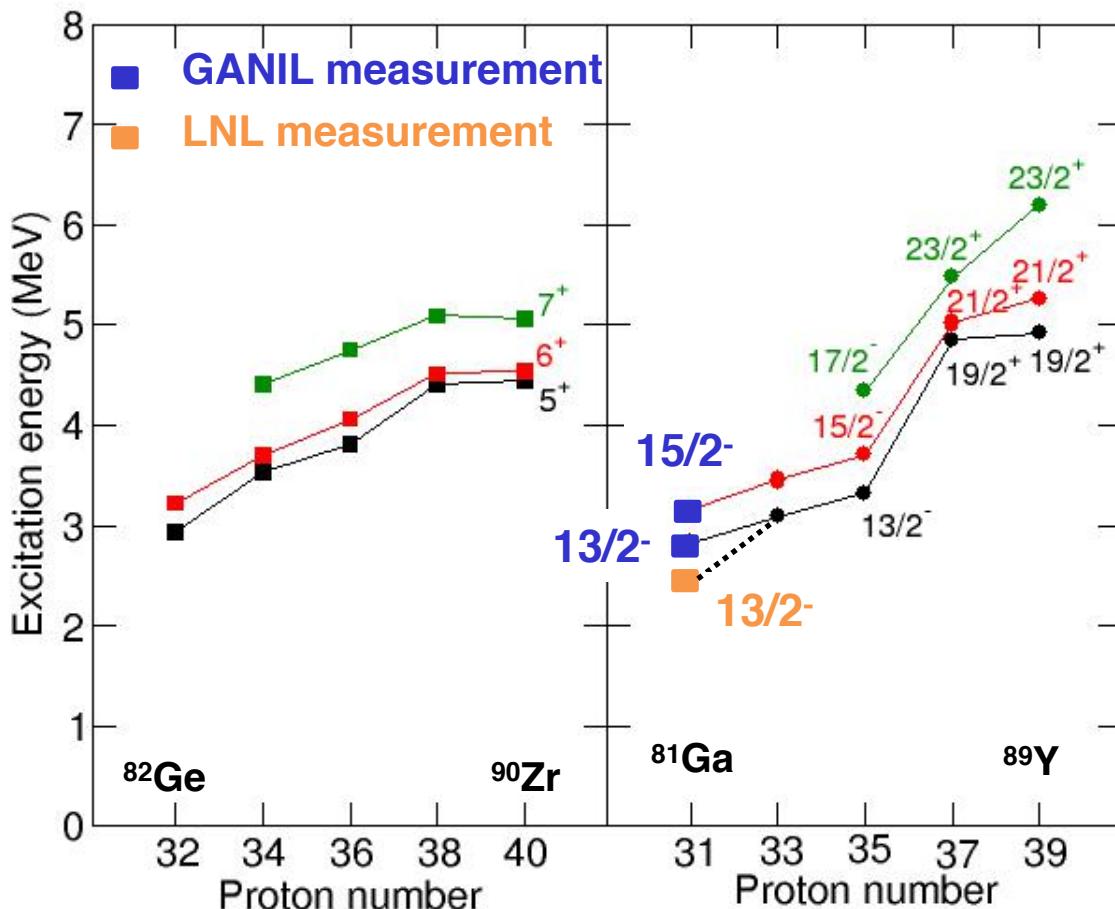
Scenario 1: GANIL level scheme is proven

The size of the N=50 gap is not drastically decreased which is in line with the mass measurements of Hakala et al., pointing an increase from Z=31.

Scenario 2: LNL level scheme is proven

The size of the N=50 gap is drastically decreased, by 400-500 keV lower which is at variance with the increasing trend of the mass measurements.

Question “why did not fusion-fission reaction populate the yrast states?” appears.



The aim of the proposal is to identify the level scheme of ^{81}Ga through the Coulomb excitation of the $9/2^-$ state

In either way such an identification will not only help us to understand:

- *The N=50 shell gap evolution closer to Z=28 (^{78}Ni)*

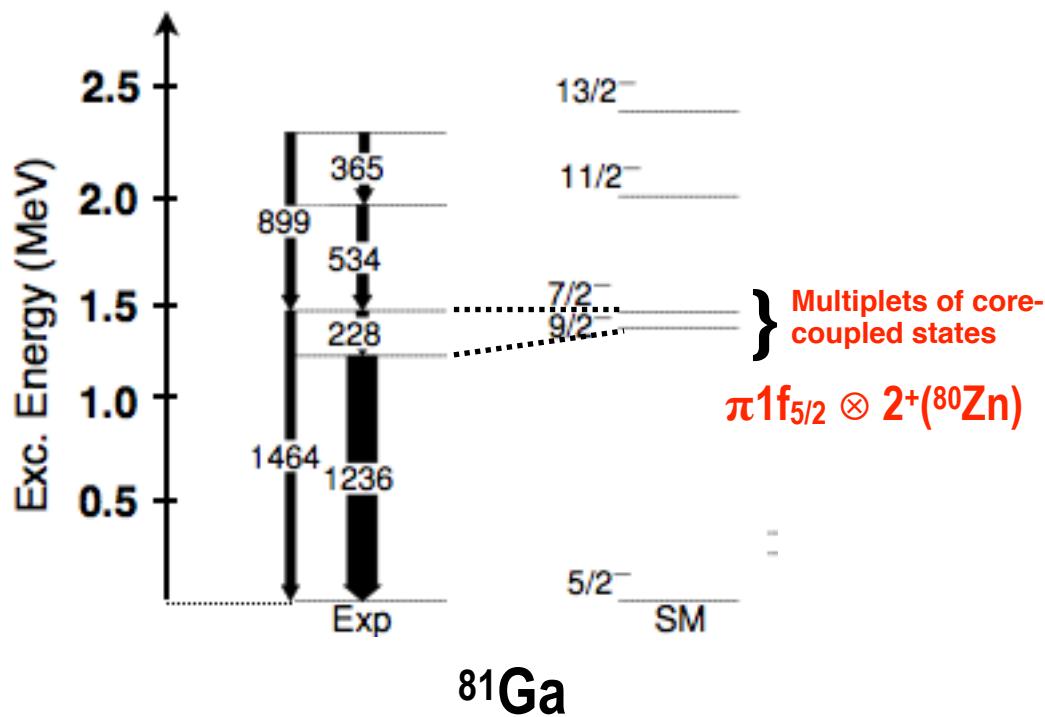
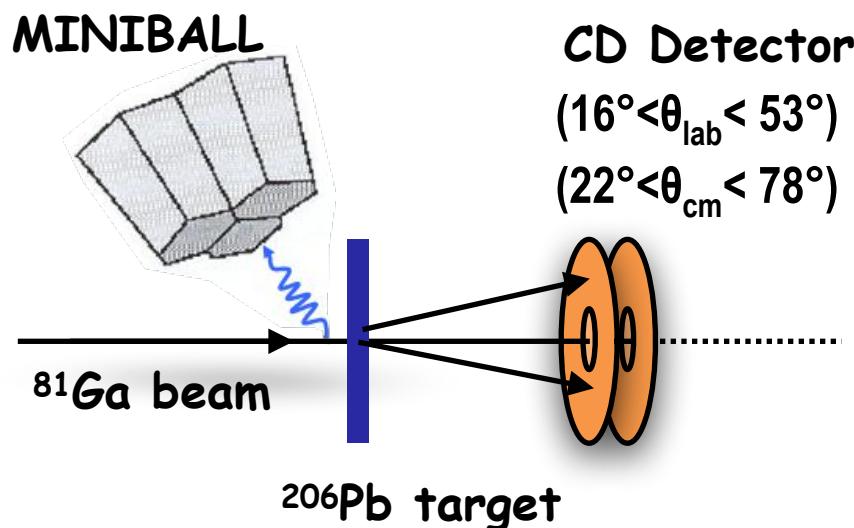
but

- *The role of the reaction mechanisms such as multi-nucleon transfer or fusion-fission reactions.*

Proposed Experiment

Coulomb excitation of ^{81}Ga

$^{81}\text{Ga} + ^{206}\text{Pb}$ @ $E(^{81}\text{Ga})=380 \text{ MeV}$



Beam time request

- Beam energy 380 MeV (4.6 MeV/nuc)
- Beam intensity on target
 - Initial beam intensity 7.5 x10³ pps
 - proton beam current 1.9 x10⁵ pps
 - Transmission on MINIBALL beam line 2%
- Target thickness 4 mg/cm²
- MINIBALL efficiency at 1.3 MeV 8%
- Yield estimation (GOSIA2):
 - $B(E2: 2^+ \rightarrow 0^+) = 730 \text{ e}^2 \text{fm}^4$ value of the ⁸⁰Zn even-even core is used for the rate calculations
 - Calculations predict ~4 times less strength in the 7/2- member of the multiplets

Transition	Energy (keV)	Number of Counts/shift
9/2- → 5/2-	1236	200
7/2- → 5/2-	1464	30
TOTAL: 12 shifts for physical runs + 3 shifts for beam preparation		



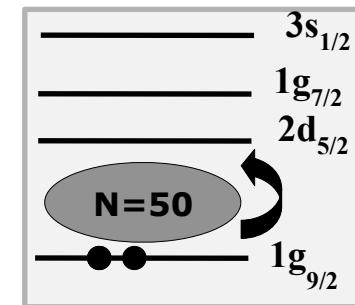
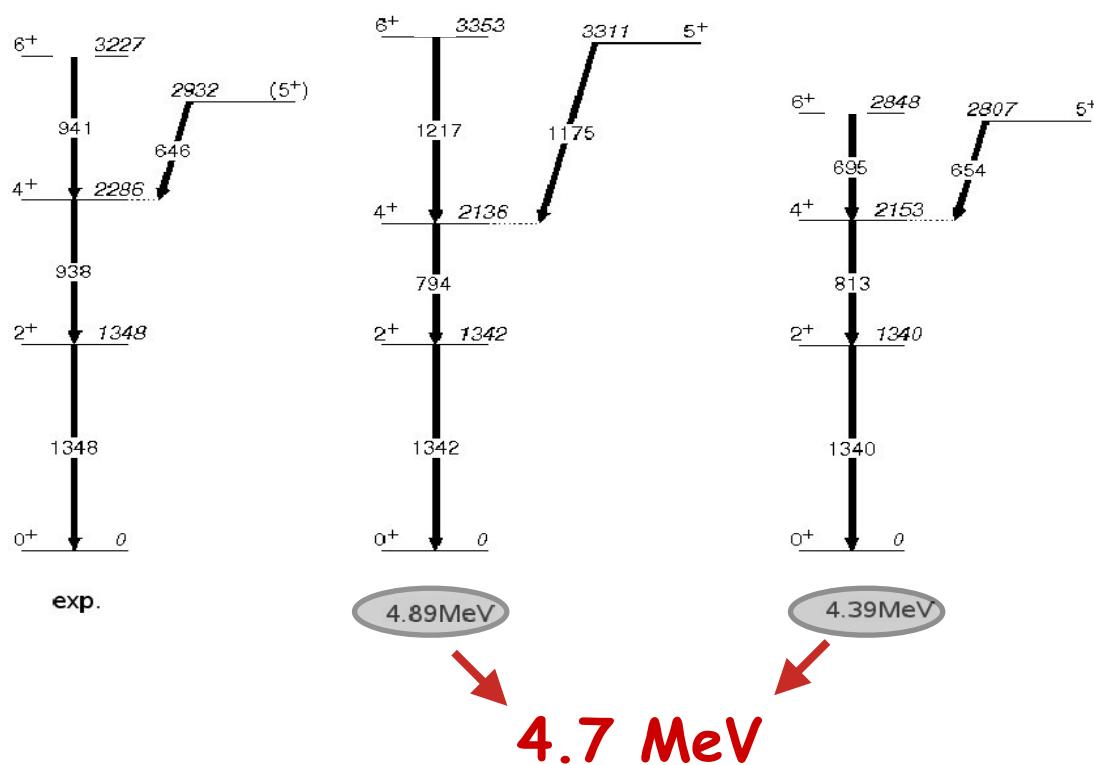
Thank you



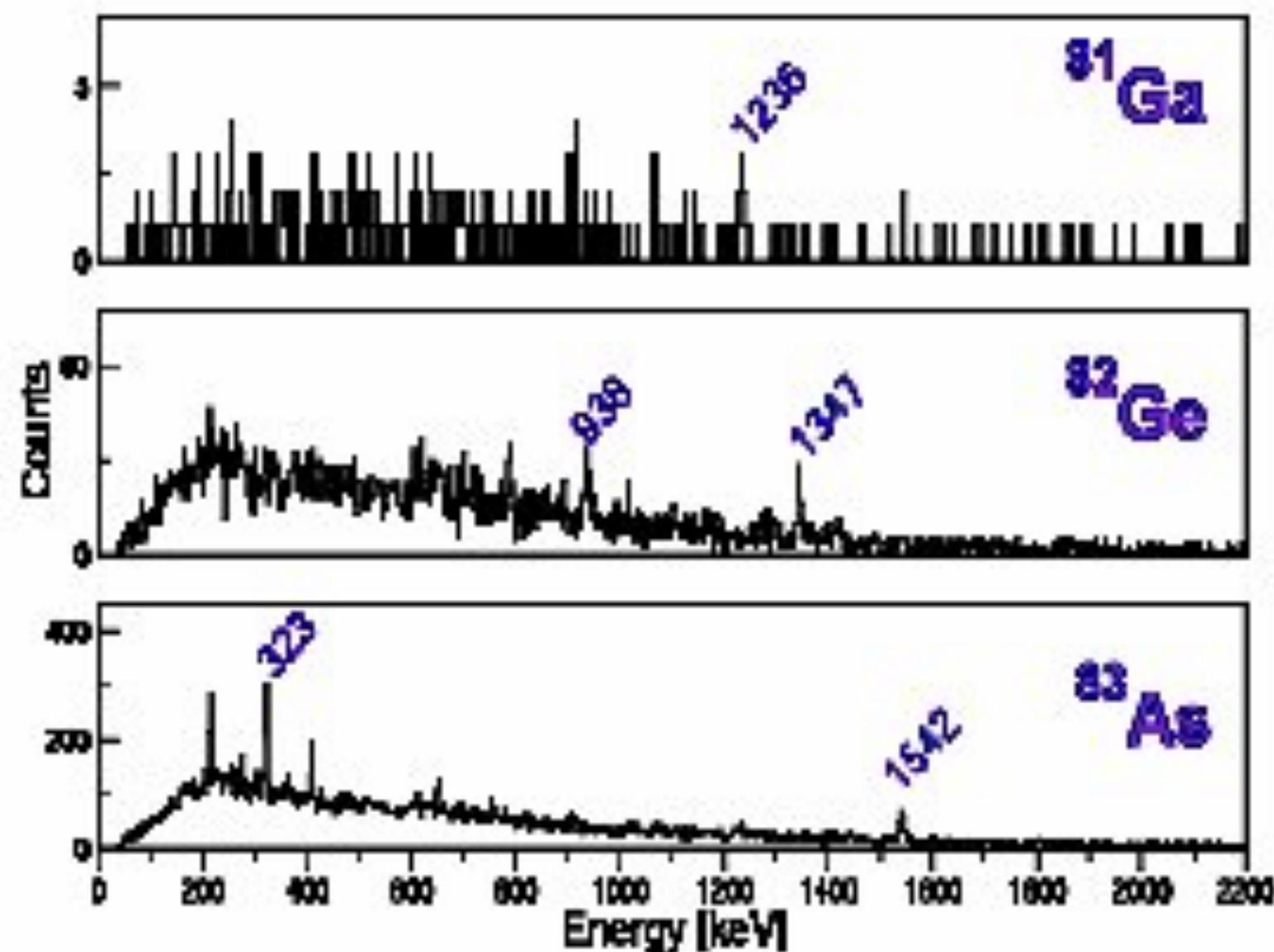
Additional slides

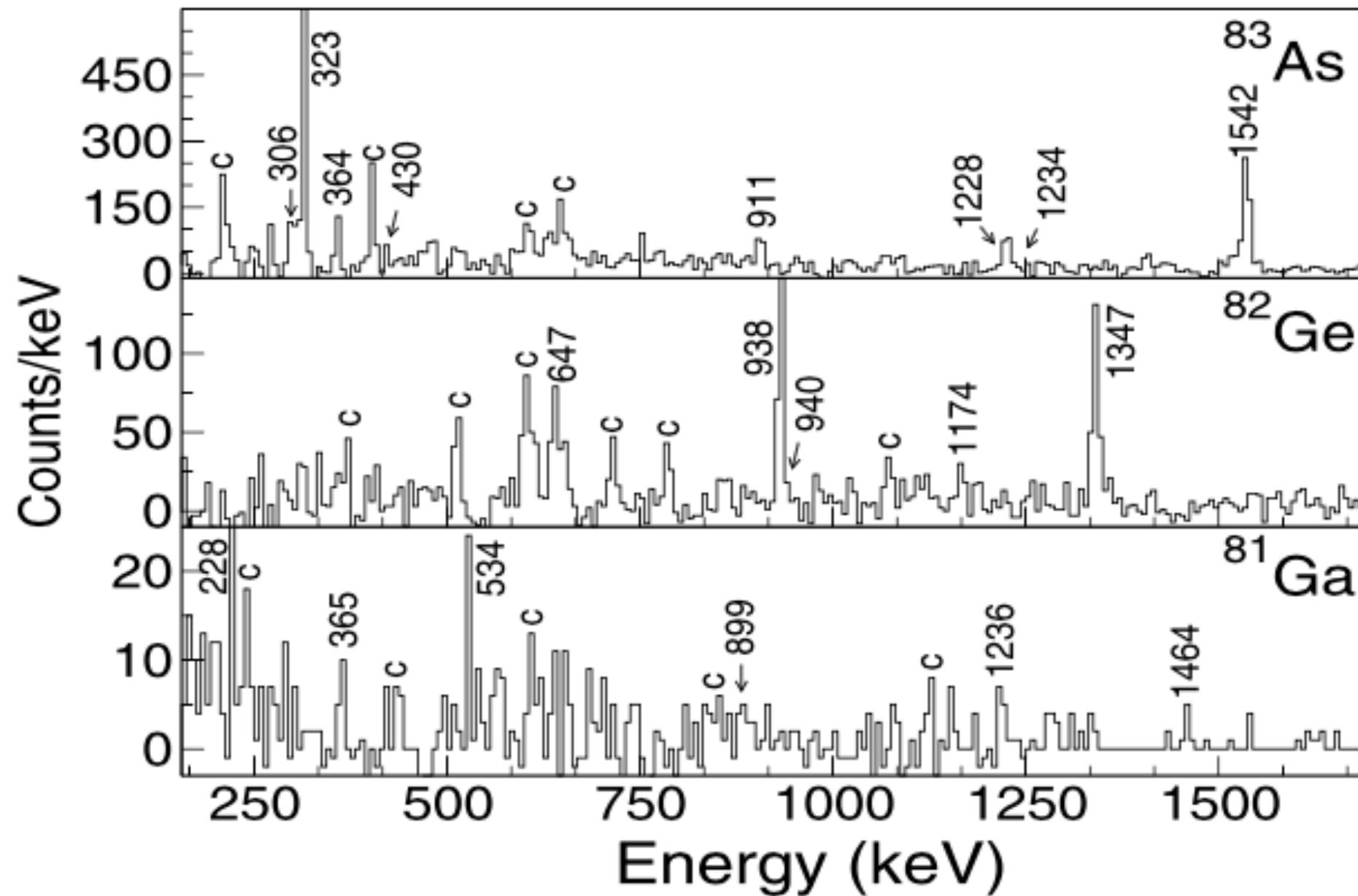
Low-lying states are mainly based on proton excitations
Information can be derived from high spin states

82Ge

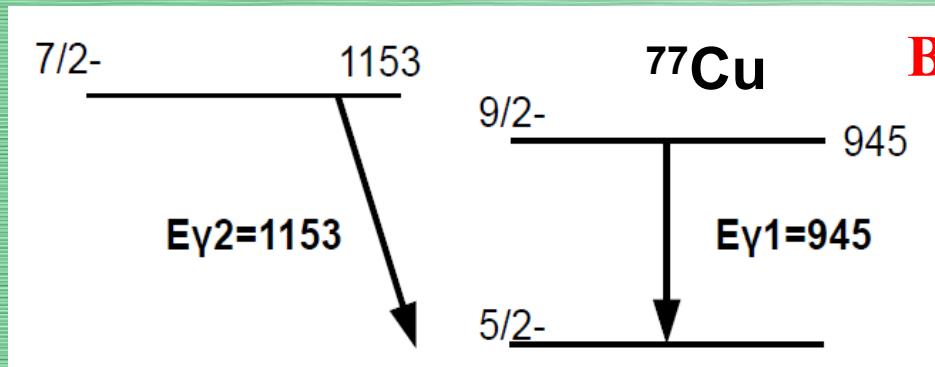


2p-2h excitations across the
 $N=50$ shell to $2d_{5/2}$ - $1g_{7/2}$ - $3s_{1/2}$
for different shell gap values

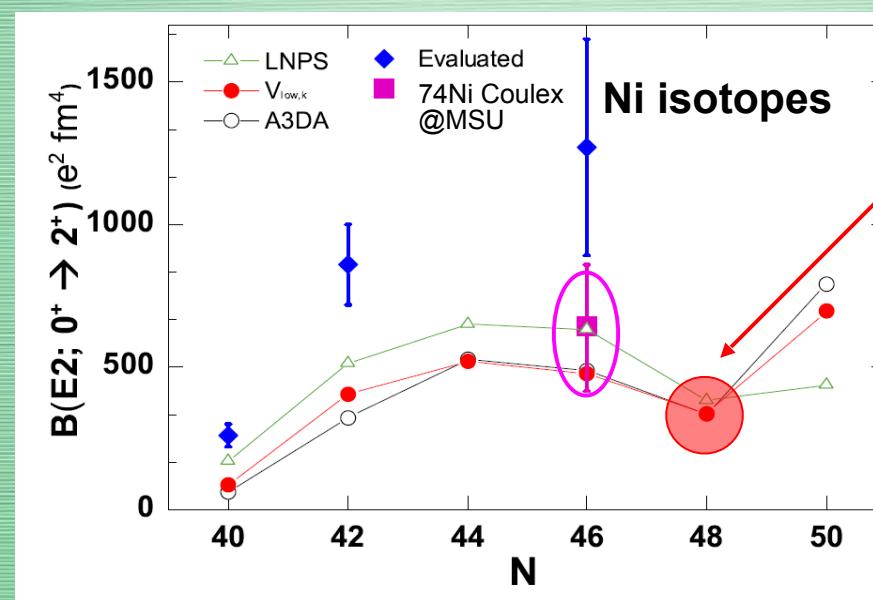




$B(E2: 5/2^- \rightarrow 7/2^-) = 41 \text{ e}^2 \text{fm}^4$ Y.Tsunoda et al.



$B(E2: 5/2^- \rightarrow 9/2^-) = 190 \text{ e}^2 \text{fm}^4$



$B(E2: 5/2^- \rightarrow 9/2^-) = 300 \text{ e}^2 \text{fm}^4$

A3DA N. Shimizu et al., Progr Theor Exp. Phys, 01A205 (2012)
 Y. Tsunoda et al., PRC 89, 031301(R) (2014)
 Y. Tsunoda et al., J.Phys.:Conf.Ser. 445, 012028 (2013)

LNPS K. Sieja, F. Nowacki, Phys Rev C 85, 051301(R) (2012)

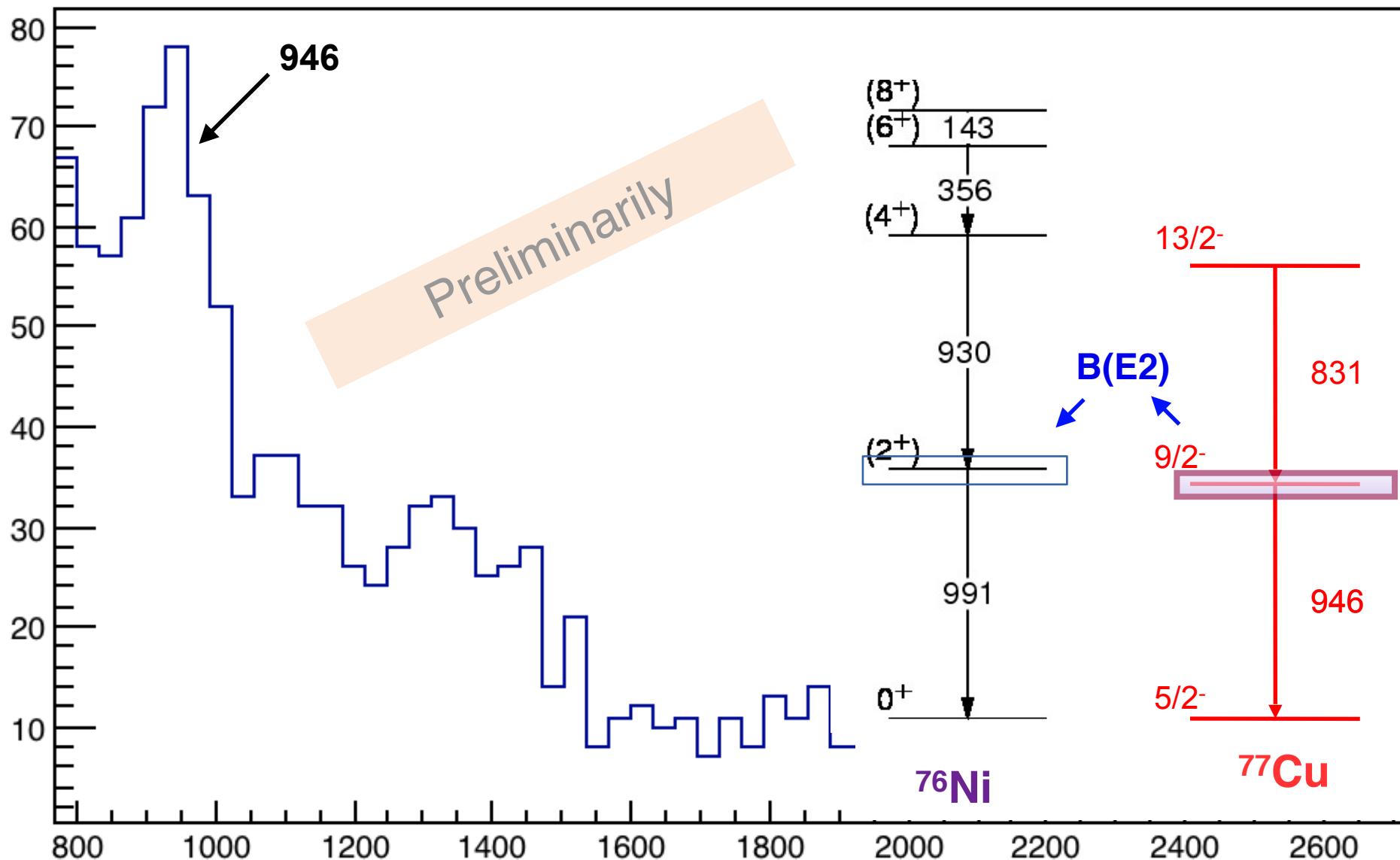
K. Sieja, F. Nowacki, arXiv:1201.0373v1 (2012)

S. M. Lenzi et al, Phys Rev C 82, 054301 (2010)

V_{low_k} L. Coraggio, PRC 89, 024319 (2014)

L. Coraggio et al., Prog. Part. Nucl. Phys 62, 135 (2009)

Gamma-ray spectrum of ^{77}Cu



Angle of ${}^{61}\text{Ga}$ [CMS-deg]

