

Nuclear structure studies of neutron-rich As, Se, Br, Kr and Rb isotopes

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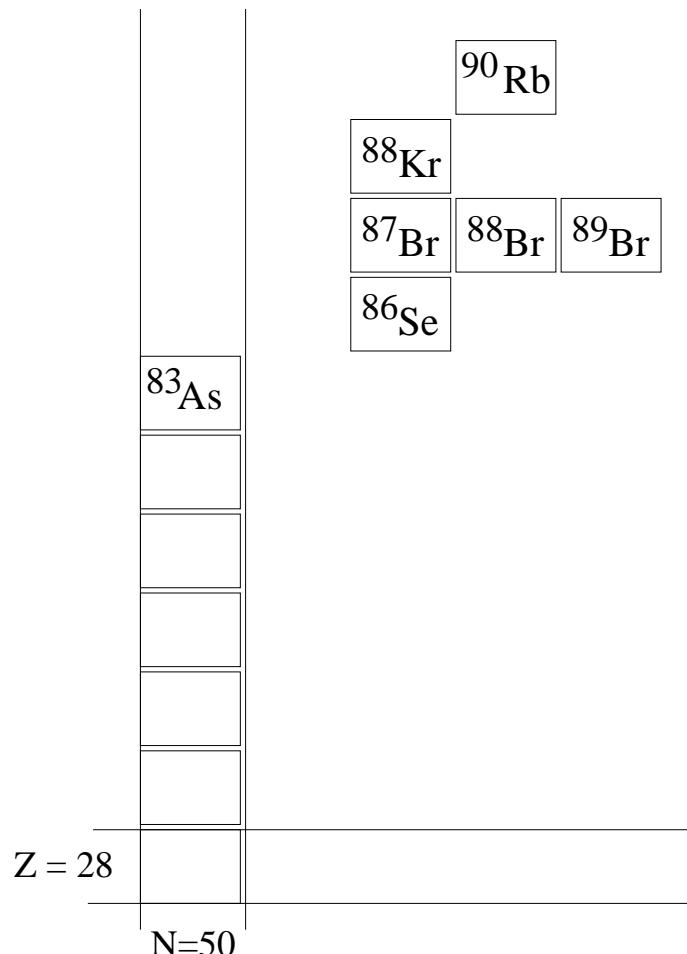
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Motivation:

- nuclear deformation and the r-process path
- mechanisms of nuclear deformation
- single-particle basis for the 78Ni region



Main results :

- „new” nuclei
- collectivity
- s.p. proton orbital $g9/2$

Deformation and the r-process

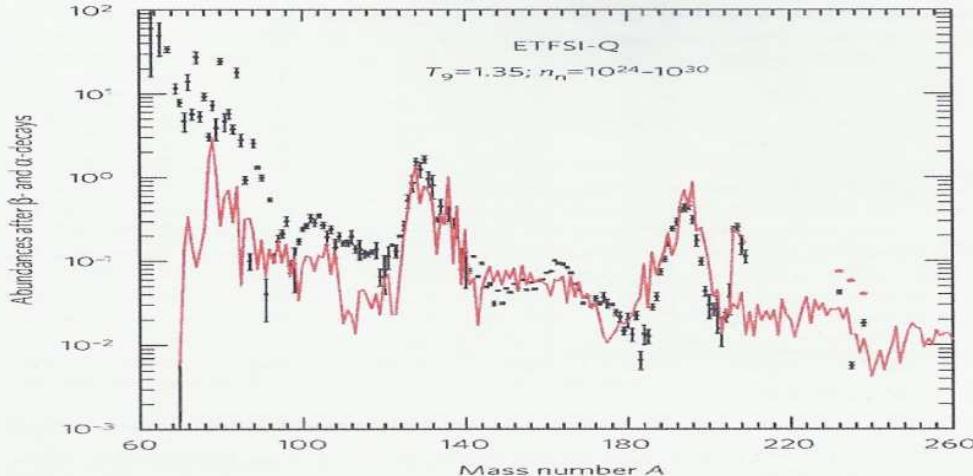
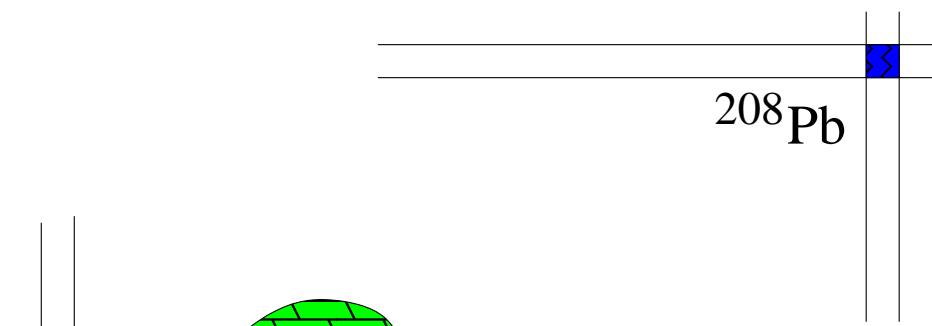
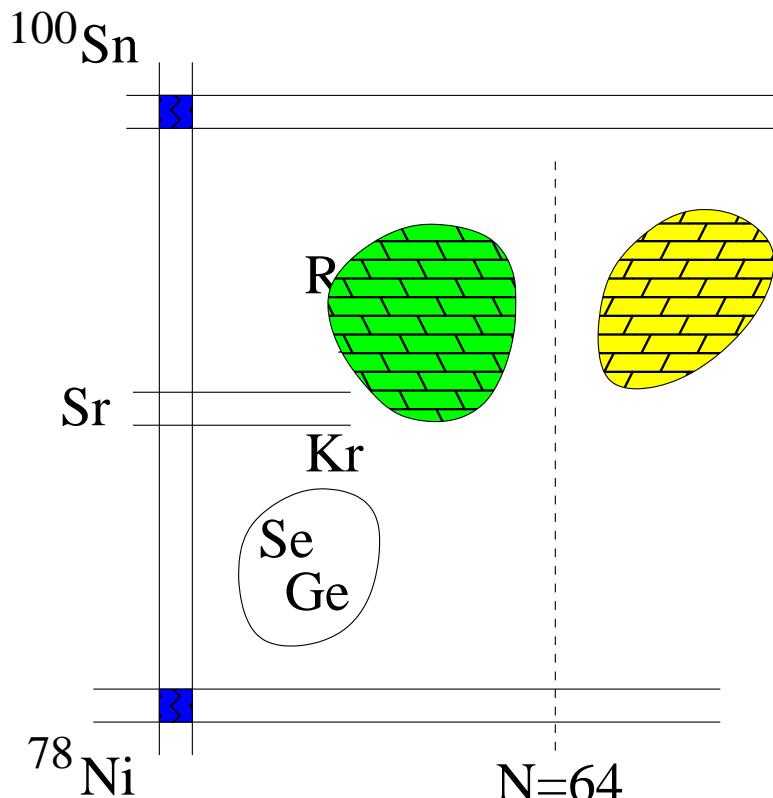


Fig. 2 Observed elemental solar abundances in the *r*-process mass range (black symbols with error bars) in comparison with calculated abundances (red line and symbols), normalized to silicon = 10^6 . The theoretical predictions show the elemental abundances for stable isotopes after α and β decay as obtained in the ETFSI-Q mass model [1, 16] for a wide range of neutron densities n_n (in $1/\text{cm}^3$) and temperatures T_9 (in units of 10^9K) and including shell quenching effects. Included with permission from [17].

D.Habs, et al. Appl. Phys. B, 2010



V.V. Simon, et al. Phys. Rev. C 85, 064308 (2012)

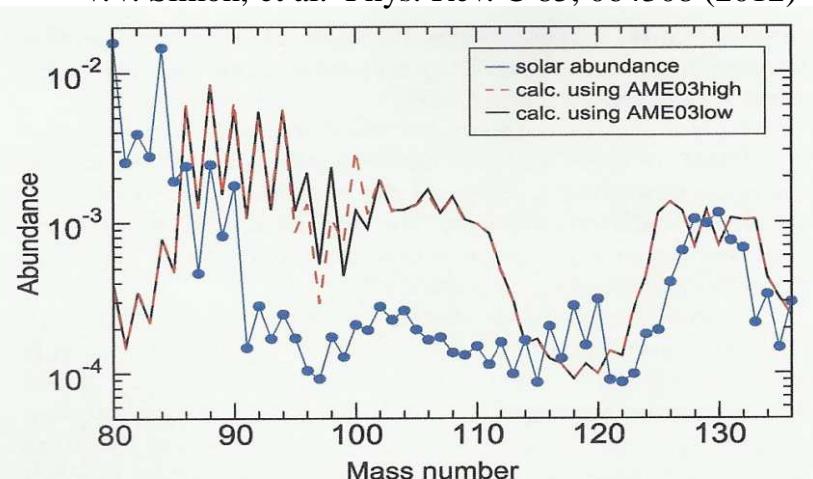
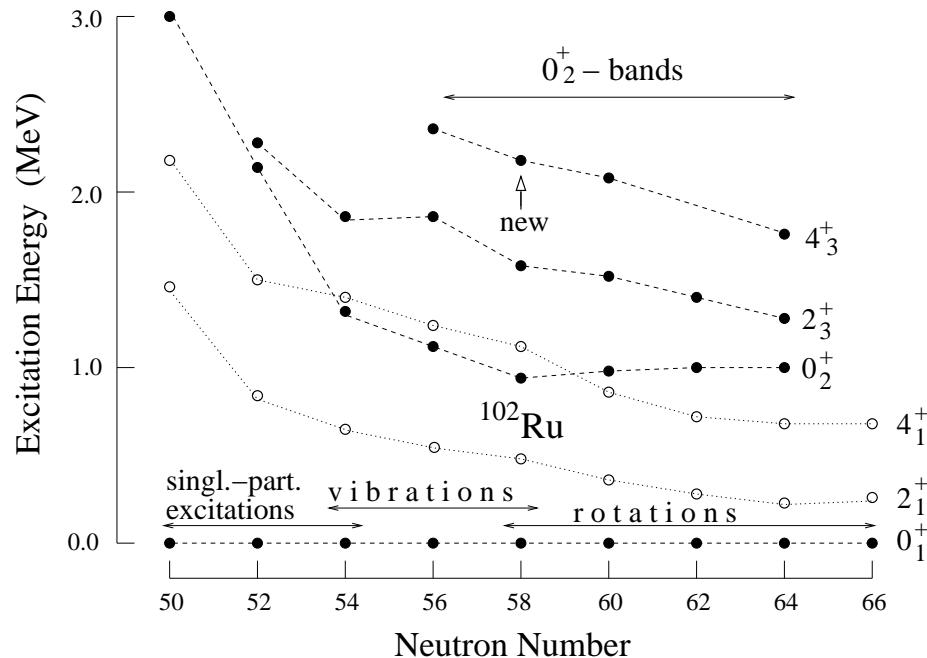


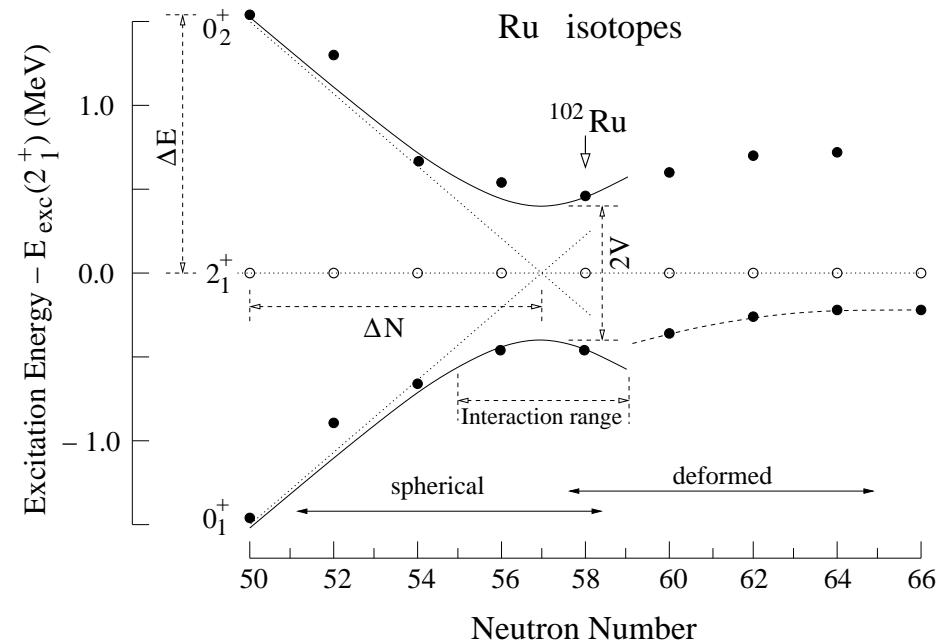
FIG. 9. (Color online) Calculated *r*-process abundances as a function of mass number summing all entropies for AME03high (dashed red) and AME03low (solid black) neutron separation energies for $^{97-99}\text{Rb}$ and $^{97-100}\text{Sr}$. Also shown for comparison are the solar *r*-process residuals (filled blue circles) [64].

Mechnisms of deformation

Ru isotopes - slow increase with neutron number (standard), also in Kr isotopes



Gamma bands and beta bands



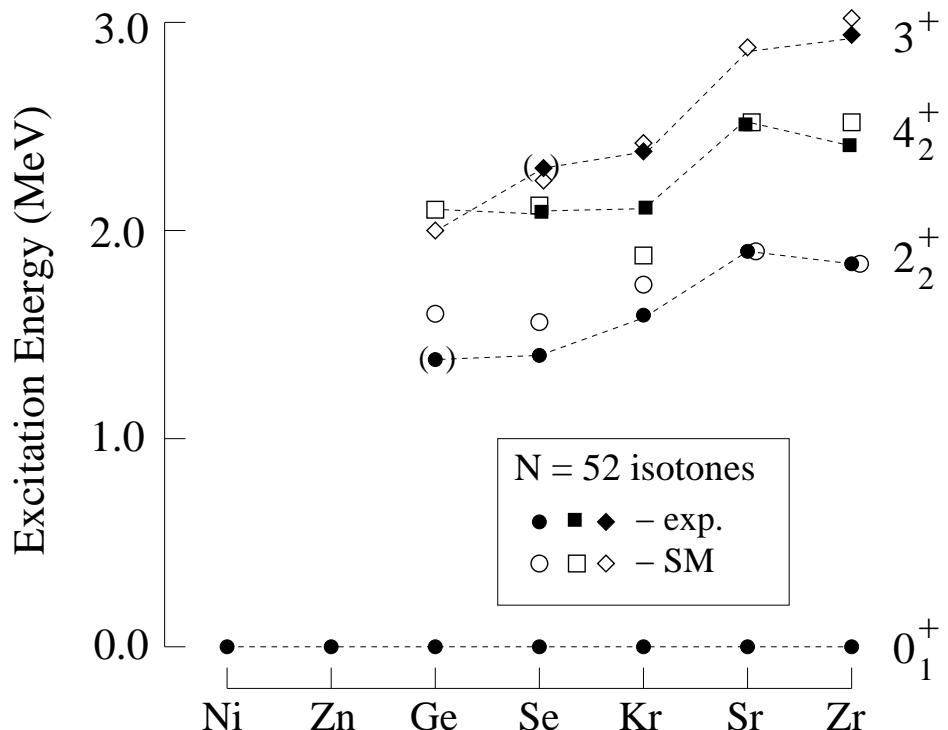
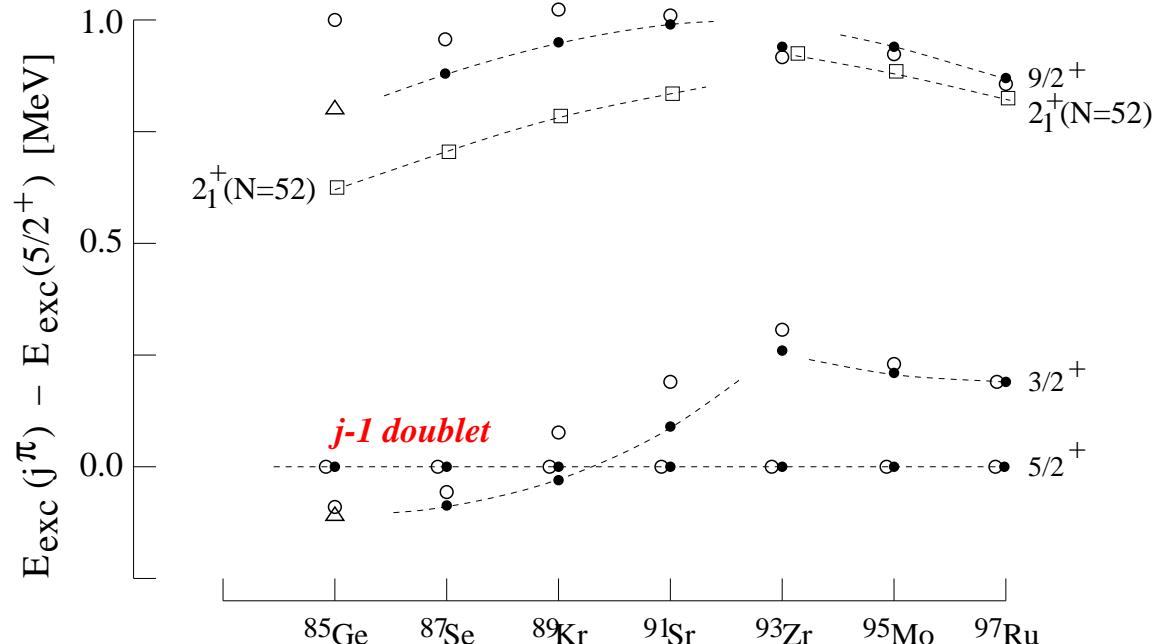
Passing deformation to the g.s. band

W.Urban , et al., Phys. Rev. C 87, 031304(R) (2013)

Se/ Ge nuclei

j-1 anomaly / pseudo SU3

T. Rząca-Urban, et al.,
Phys. Rev. C 88, 034302 (2013)

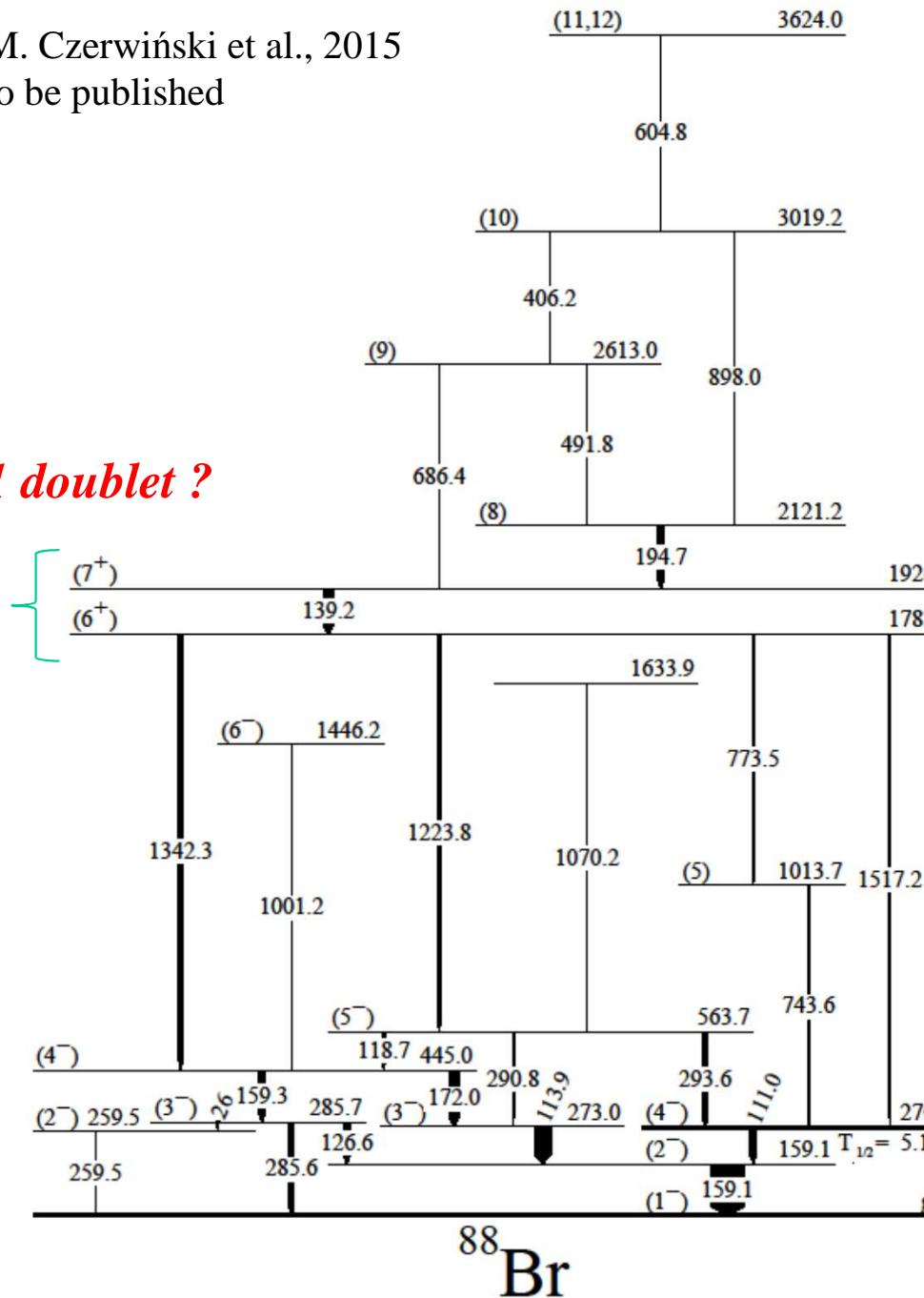


gamma collectivity

T. Materna et al., 2015
to be published

Results for ^{88}Br and ^{90}Rb - s.p. proton $g9/2$ energy and collective effects

M. Czerwiński et al., 2015
to be published

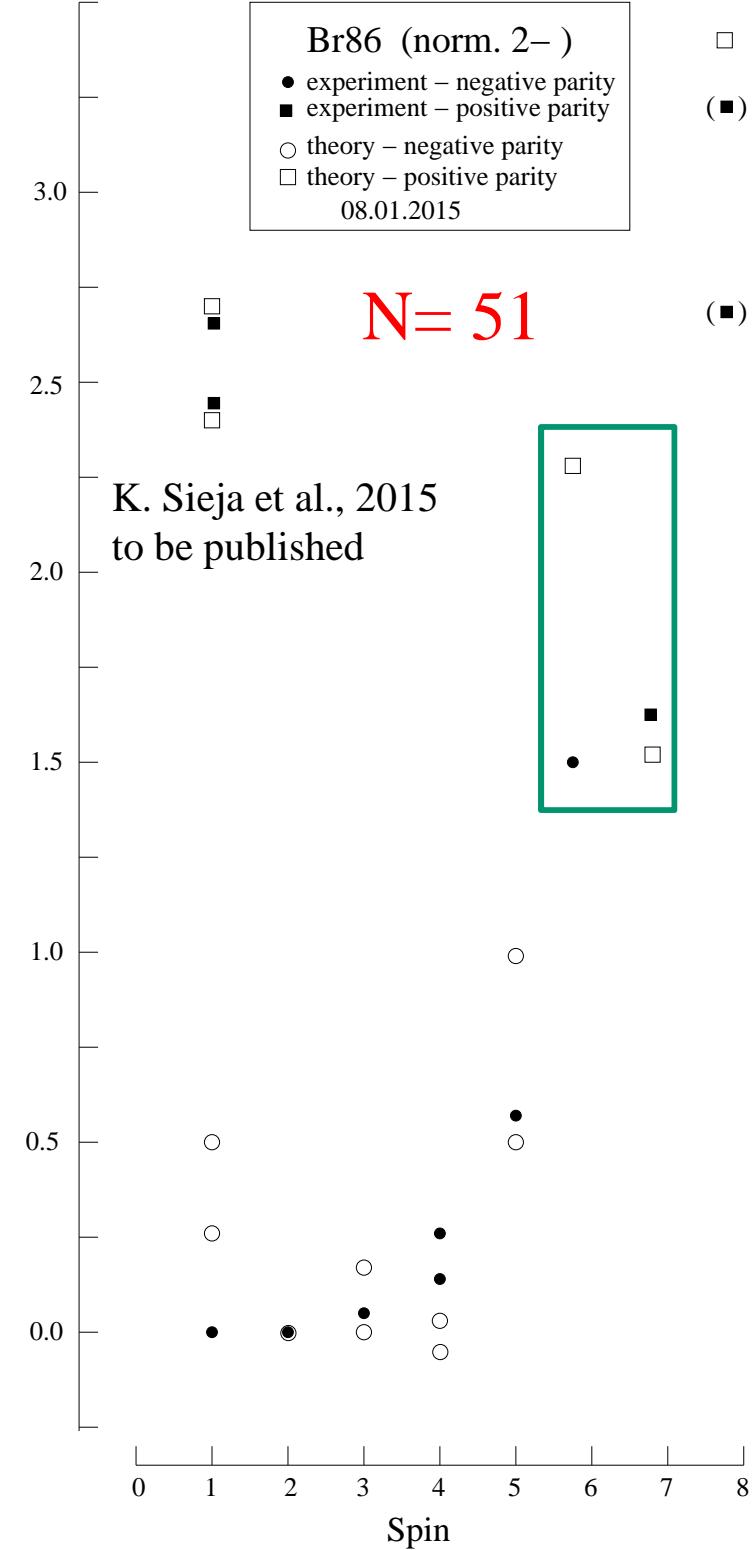
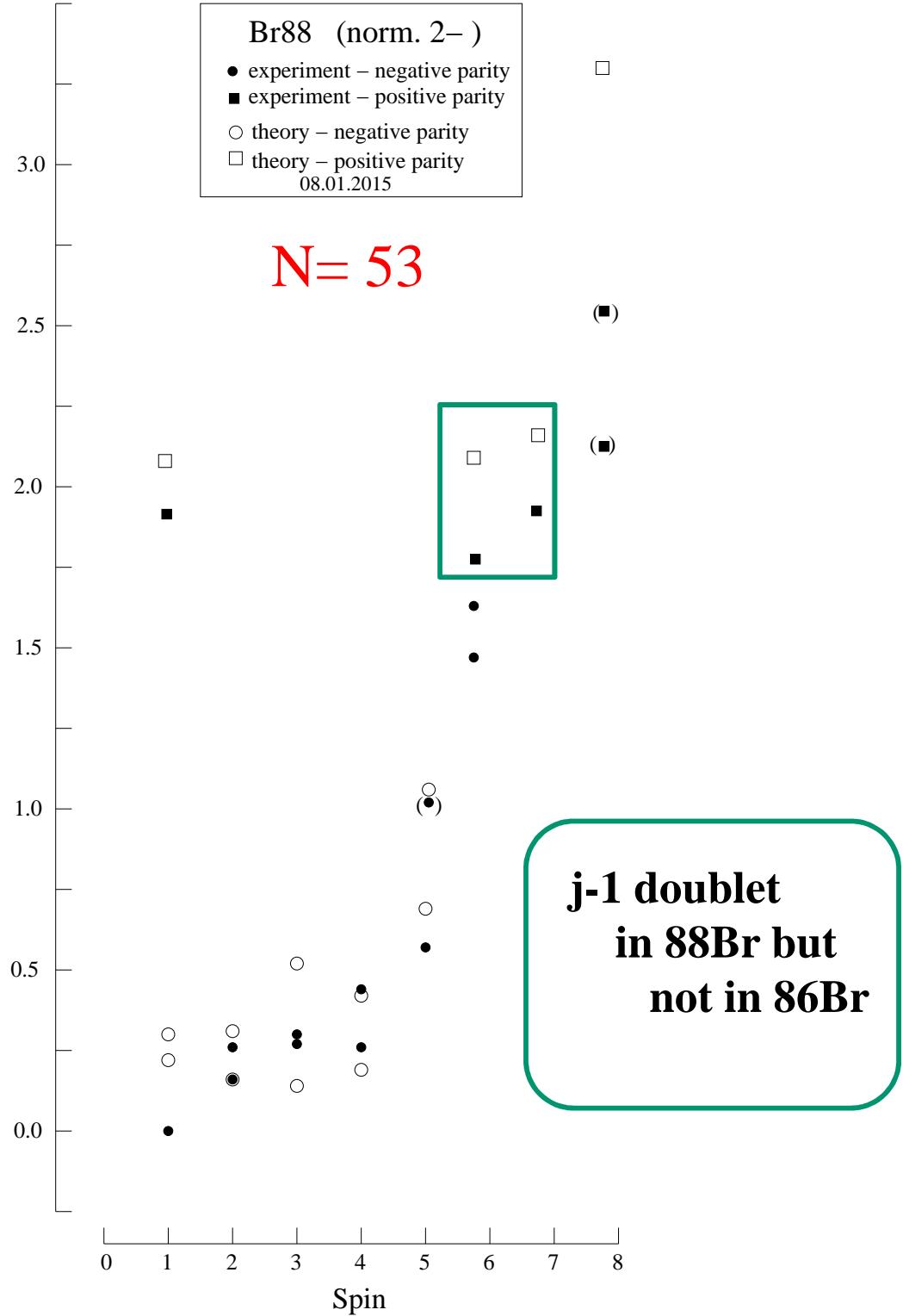


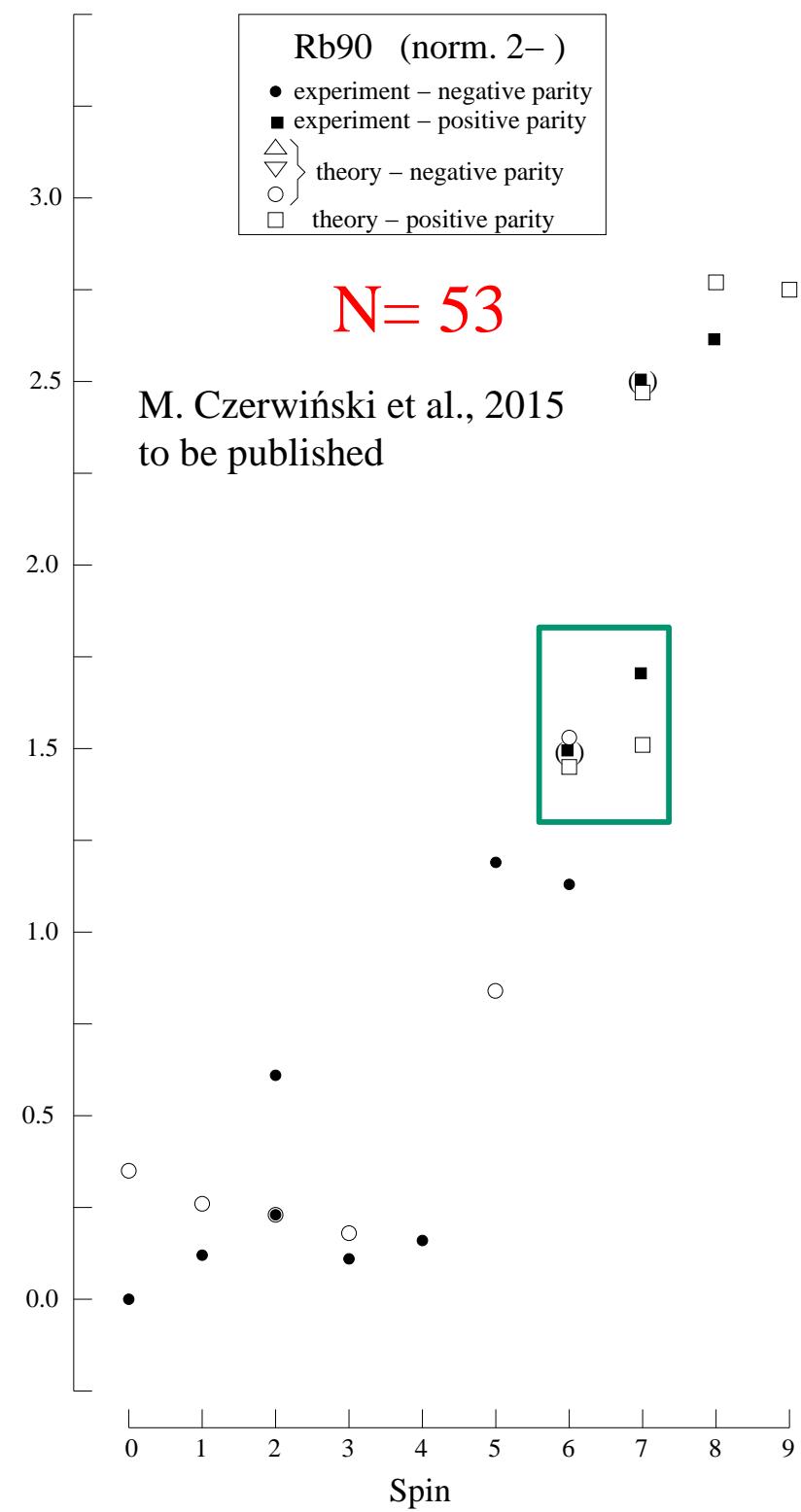
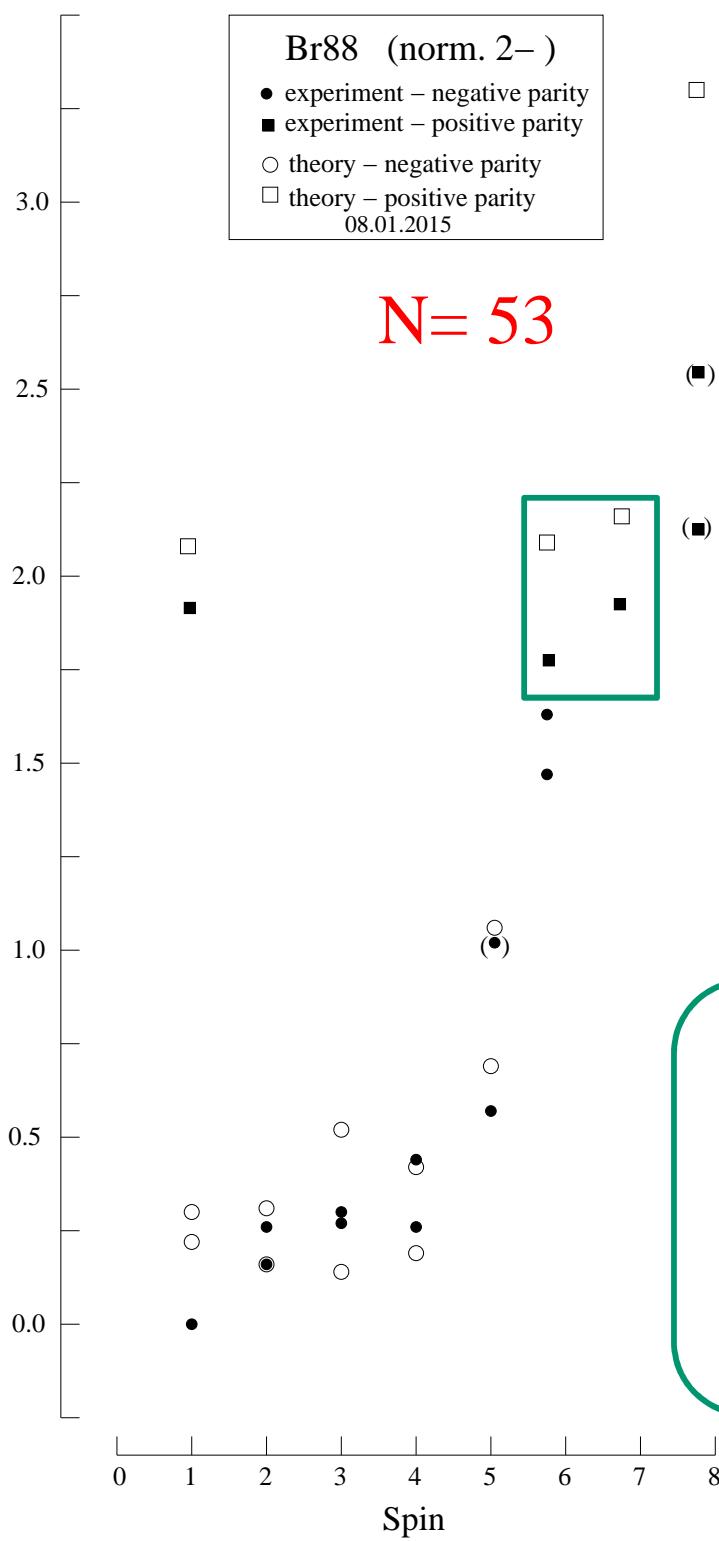
Proton-neutron multiplets :

$g9/2 \text{ d}5/2$

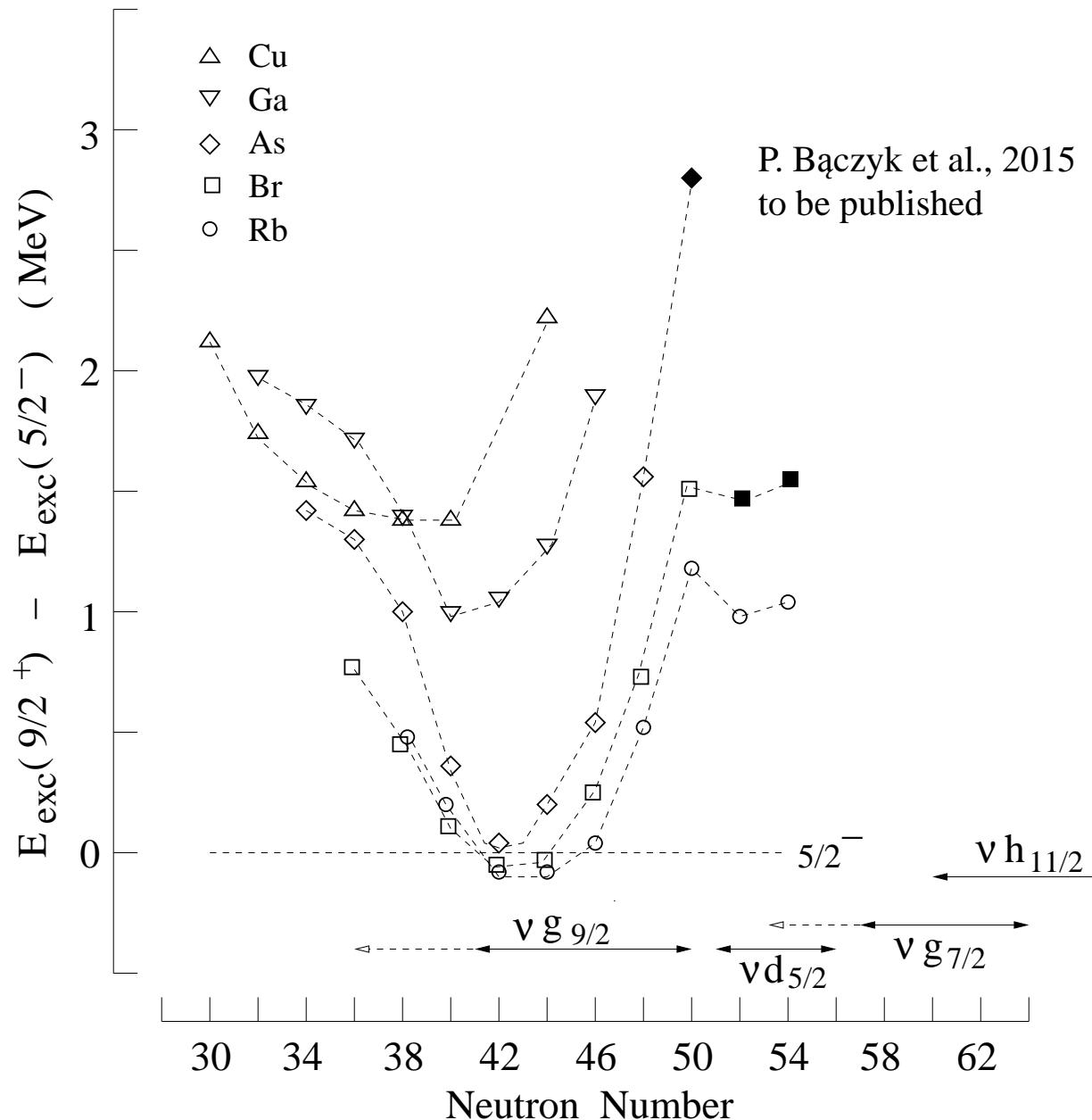
$p3/2 \text{ d}5/2$

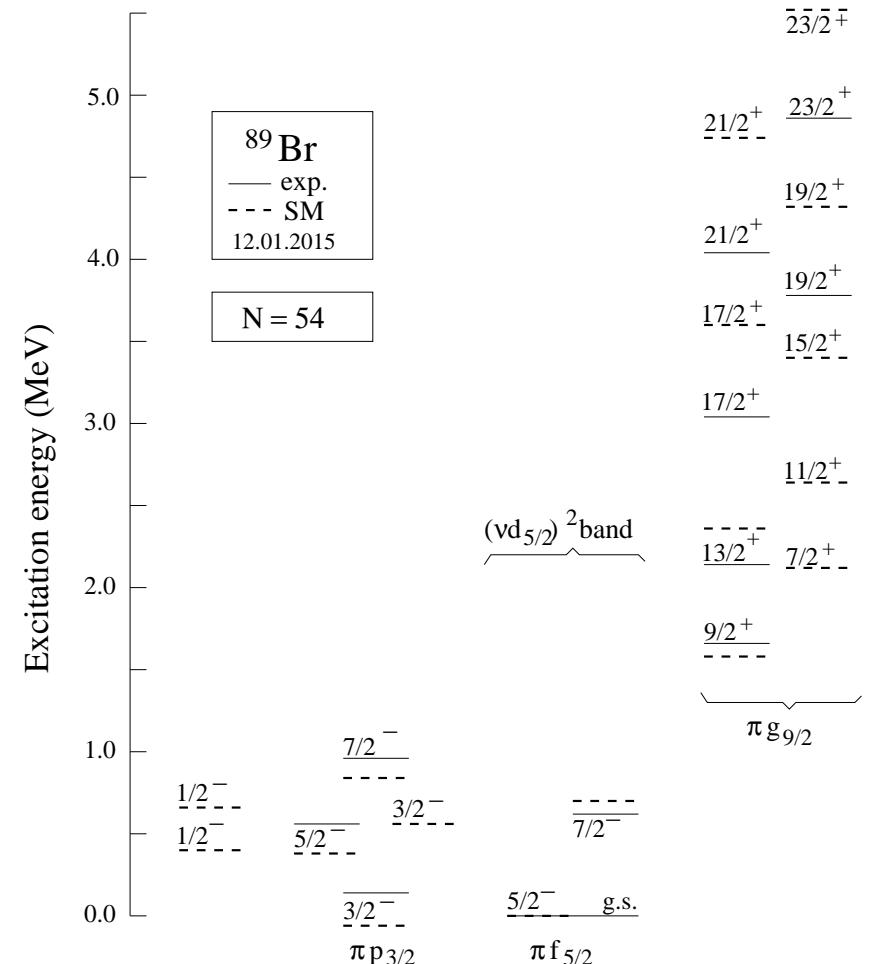
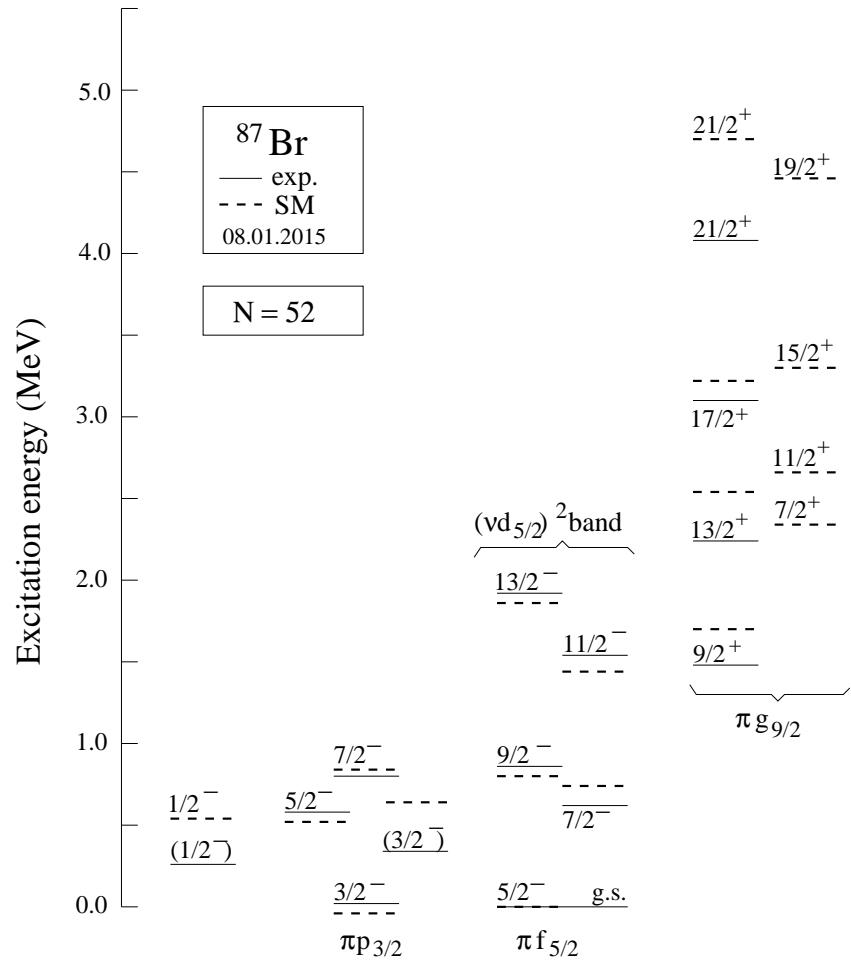
$f5/2 \text{ d}5/2$





Results for ^{83}As and $^{87}\text{Br}, ^{89}\text{Br}$ Rb - s.p. proton g9/2 energy

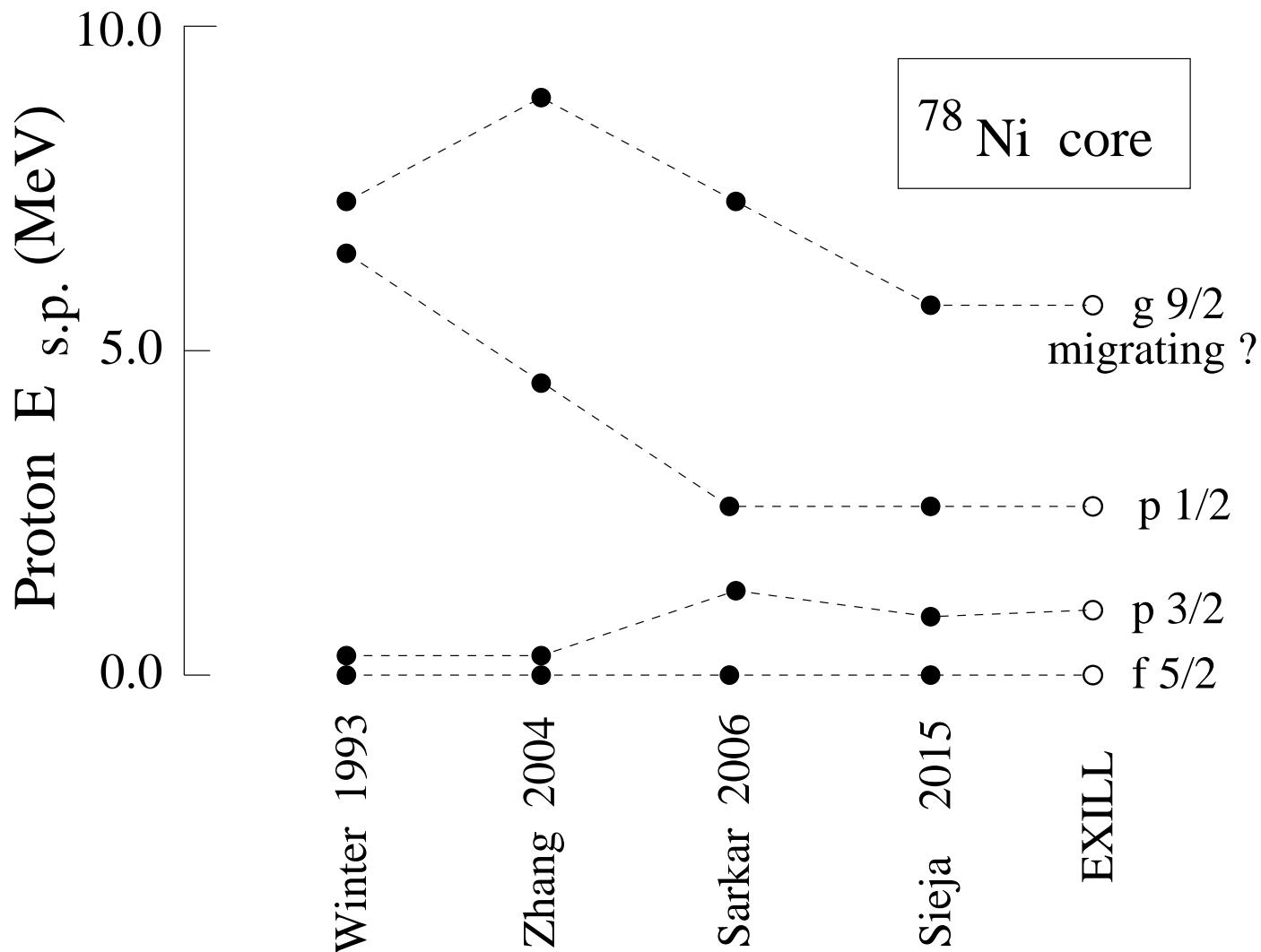




- good reproduction of $9/2^+$ levels in ^{87}Br and ^{89}Br
- new ground state in ^{87}Br
- first observation of excited levels in ^{89}Br

J. Timar, B.Nyako, et al., 2015
to be published

New s.p. proton levels for the ^{78}Ni region



Summary and Perspectives

- EXILL - quiet revolution in the $80 < A < 90$ region
- Neutron levels !
- Repeat the measurement with better energy resolution
- U233 target !
- Further analysis
 - Pu241 target
 - FATIMA data
 - (n,gamma)

C. The role of protons in the onset of deformation. Regions of deformation.

W.Urban , et al., Eur.Phys. J A20, 381 (2004)

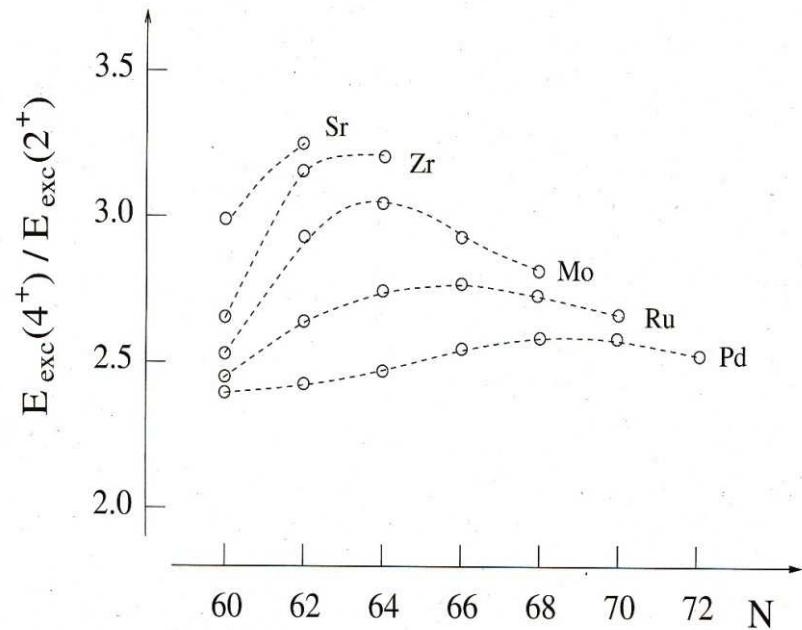


Fig. 4. The $E(4^+)/E(2^+)$ ratio for even-even nuclei of the ~ 110 region. The data are form this work and refs. [3,6,9, 10]. Dashed lines are drawn to guide the eye.

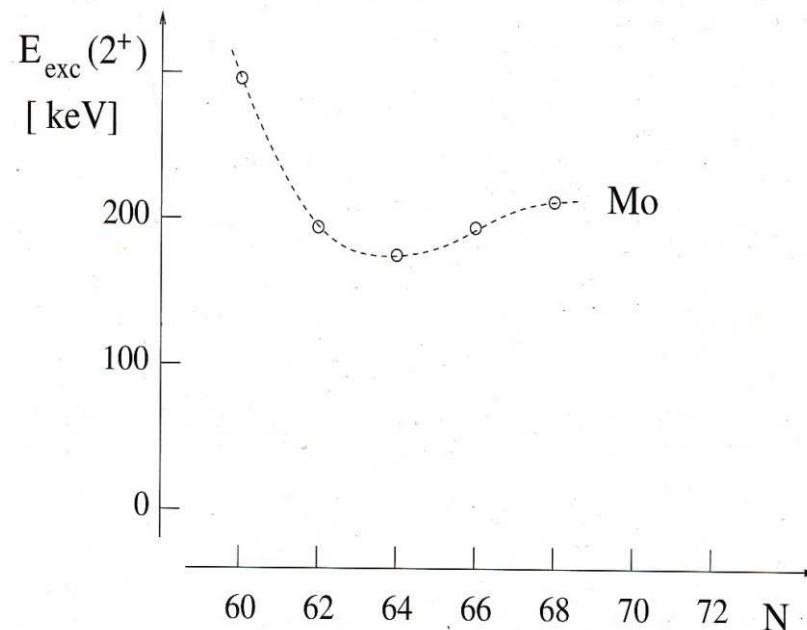
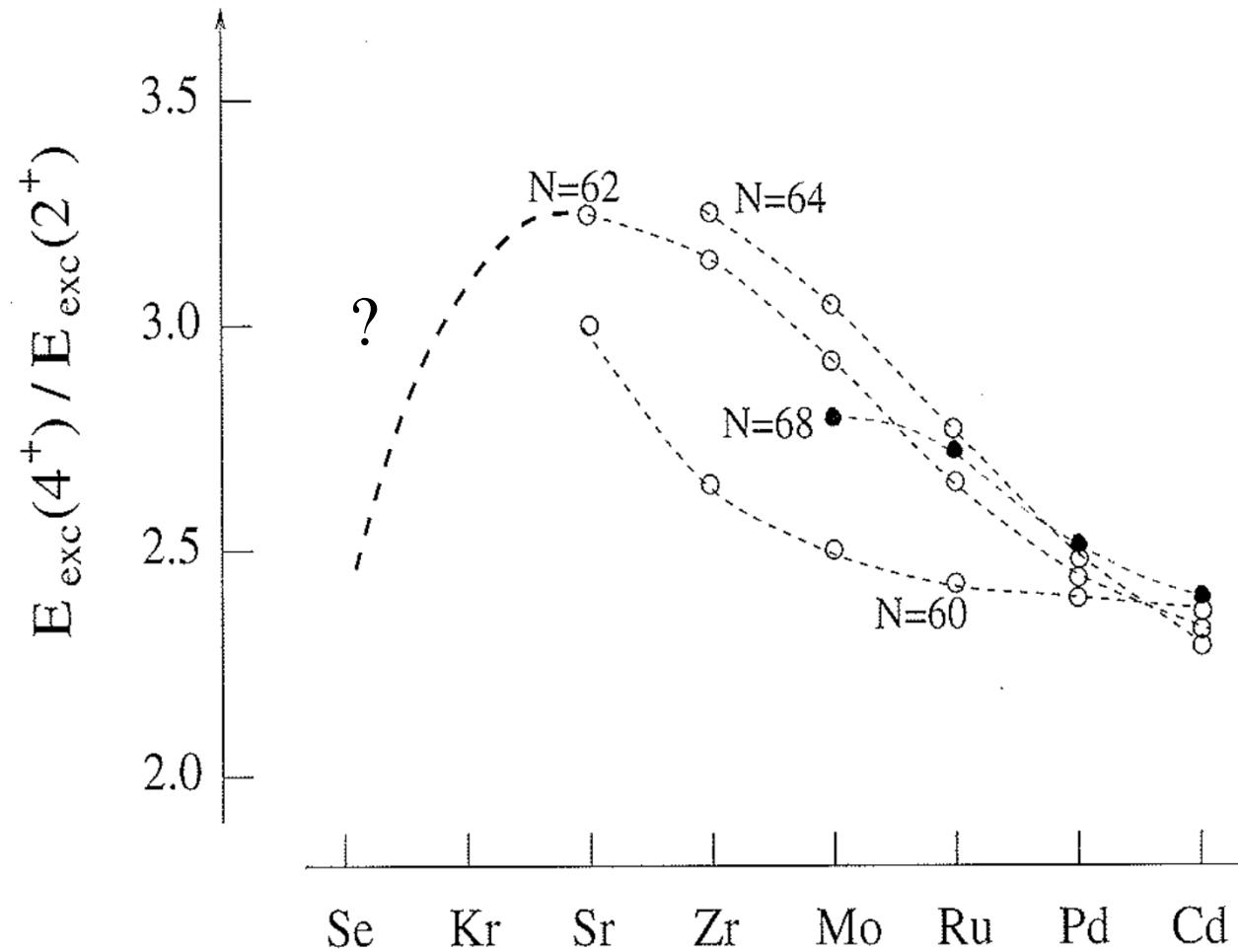


Fig. 5. The $E(2^+)$ excitation energy in even-even Mo nuclei of the $A \sim 110$ region. The data are form this work and refs. [6, 10]. The dashed line is drawn to guide the eye.

- deformation grows up to $N=64$ and then drops
- deformation grows from Ru to Sr and then ?
- new deformation (oblate?) past $N=66$?



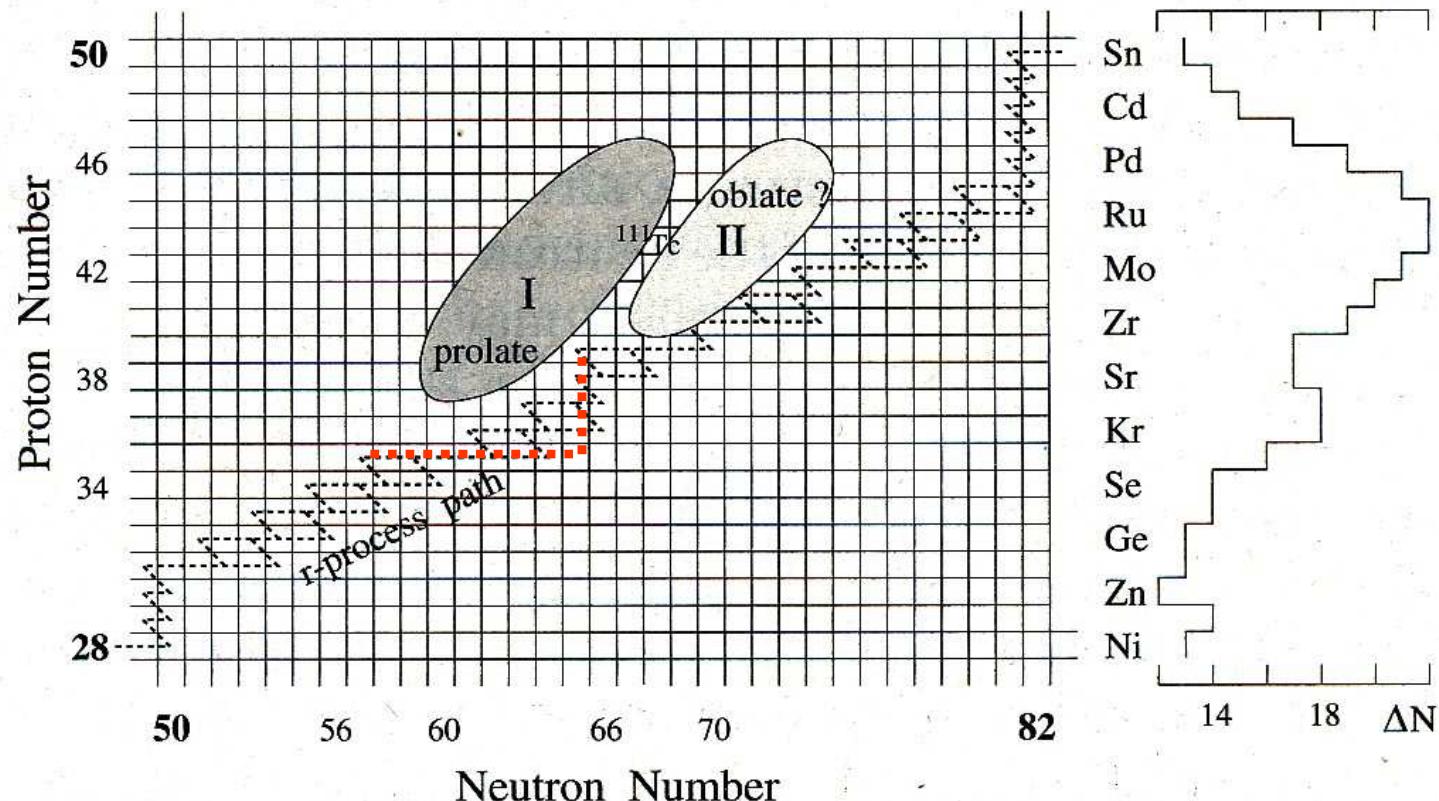


Fig. 1. Approximate regions of nuclear deformations and the approximate position of the r-process path in the $28 < Z < 50$, $50 < N < 82$ region. To the right, the distance, ΔN , from the stability line to the path, is shown for various isotopes.