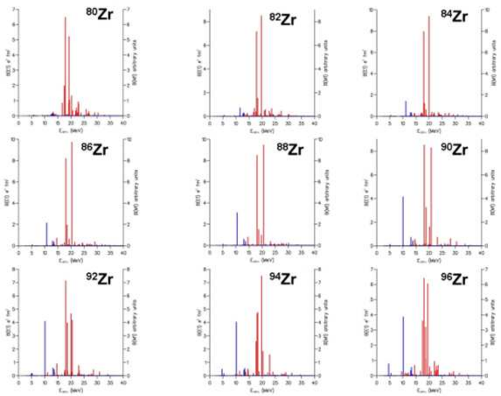
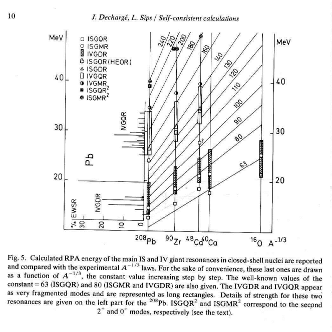




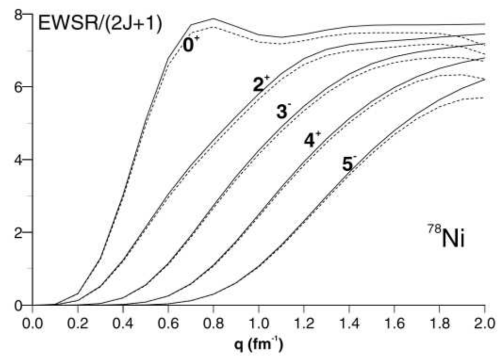
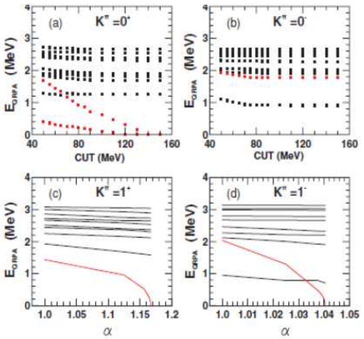
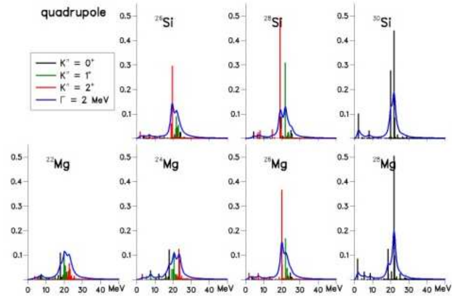


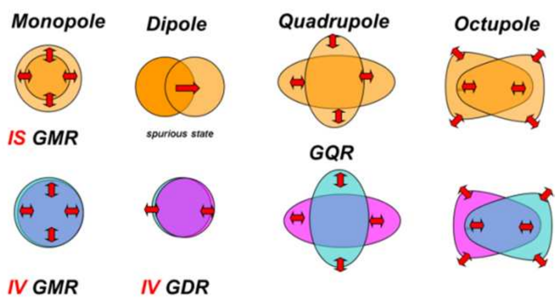
Fig. 1. Comparisons between the exact EWSR of eq. (3) (solid line) and those deduced from eq. (2) (dotted line) in ^{78}Ni for the RPA states with $J^\pi = 0^+, 2^+, 3^-, 4^+$ and 5^-. The unit of the EWSR scale is e^2 MeV. The abscissa q represents the transferred momentum.

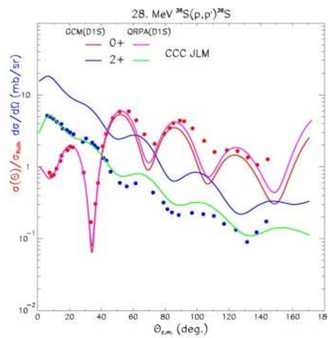
Excitations and QRPA calculations with the Gogny force

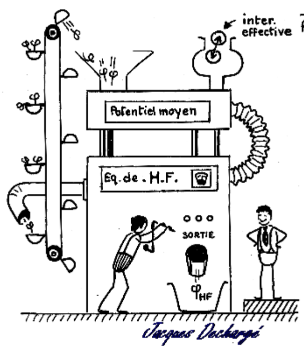




Sophie Péru
&
Marco Martini
Marc Dupuis







QRPA formalism

HFB+QRPA

$$\theta_n^+ = \sum_{ij} X_n^{ij} \beta_i^+ \beta_j^+ + Y_n^{ij} \beta_{\bar{j}} \beta_{\bar{i}}$$

{β⁺ β} qp creation and annihilation operators.

θ are solution of

$$\begin{pmatrix} A & B \\ B^* & A^* \end{pmatrix} \begin{pmatrix} X \\ Y \end{pmatrix} = \omega \begin{pmatrix} X \\ -Y \end{pmatrix},$$

$$|n\rangle = \theta_n^+ |\tilde{0}\rangle.$$

In our approach, The effective interaction D1S is used both in the HFB mean field and in the QRPA matrix.

In axial symmetry , QRPA states {θ+} are obtained for each block K^π ($K^\pi \le J^\pi$)

Restoration of rotational symmetry for deformed states

$$|JM(K)\rangle = \frac{\sqrt{2J+1}}{4\pi} \int d\Omega D^J_{MK}(\Omega) R(\Omega) |\theta_K\rangle + (-)^{J-K} D^J_{M-K}(\Omega) R(\Omega) |\bar{\theta}_K\rangle$$

We want to calculate: $\langle \tilde{0} | \hat{Q}_{\lambda\mu} | JM(K) \rangle$ **for all QRPA states (K ≤ J)**

For example: $J^\pi = 2^+$ $\hat{Q}_{20} = \sum r^2 (Y_{20})$ **In intrinsic frame** $r^2 Y_{\lambda\mu} = \sum_\nu D^\lambda_{\mu\nu} r^2 Y_{\lambda\nu}$

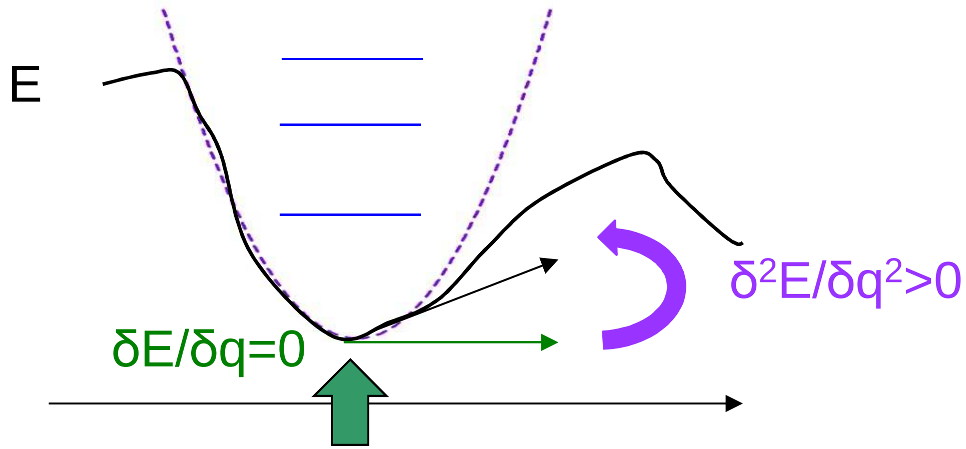
Using rotational approximation and relations for 3j symbols

$$\langle \tilde{0} | \hat{Q}_{20} | JM(K) \rangle = \frac{1}{\sqrt{5}} \langle 0 | \hat{Q}_{20} | \theta_K \rangle \delta_{K,0} + \frac{\sqrt{3}}{\sqrt{5}} \langle 0 | \hat{Q}_{2-1} | \theta_K \rangle \delta_{K,\pm1} + \frac{\sqrt{3}}{\sqrt{5}} \langle 0 | \hat{Q}_{22} | \theta_K \rangle \delta_{K,\pm2}$$

Using time reversal symmetry, three independent calculations ($K^\pi = 0^+, 1^+, 2^+$) **are needed.**

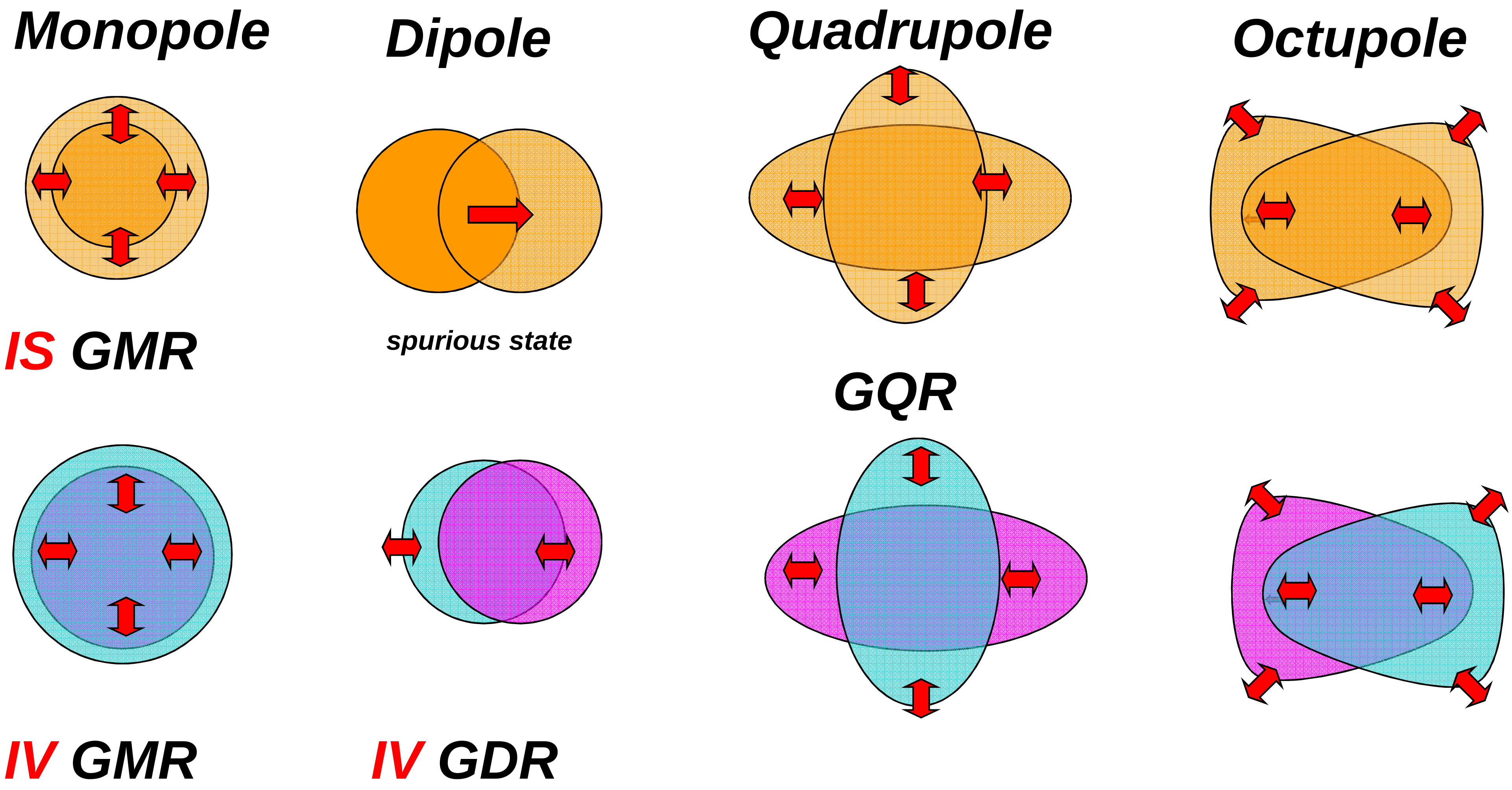
RPA approaches describe
all multipolarties and all parities,
collective states and individual ones,
low energy and high energy states
with the same accuracy.

Within the small amplitude approximation, i.e. « harmonic » nuclei



High energy collective states: giant resonances

Giant resonances are related to nuclear matter properties

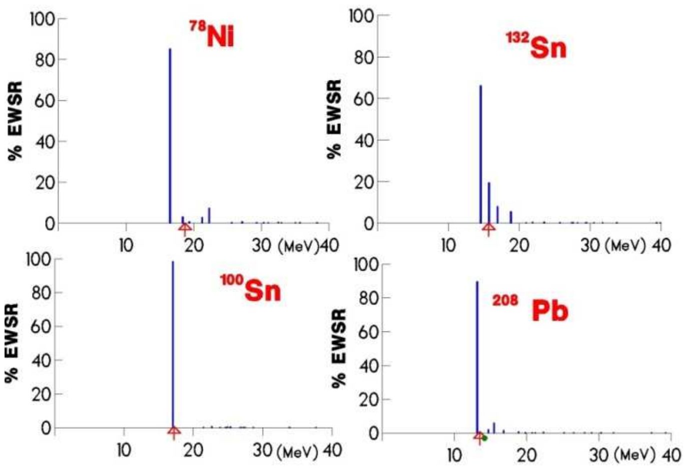


RPA in spherical symmetry

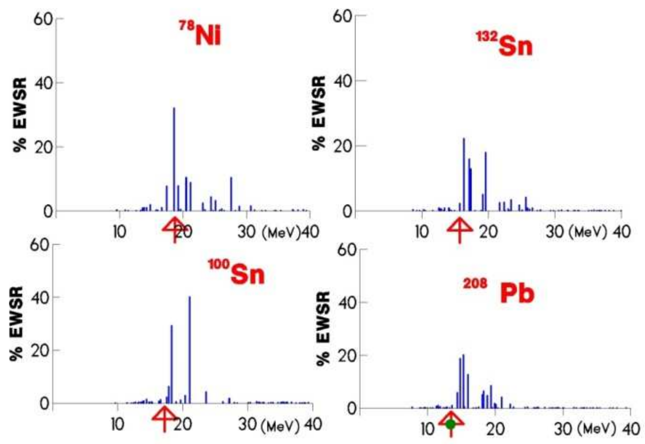
Giant resonances in exotic nuclei:

^{100}Sn, ^{132}Sn, ^{78}Ni; S. Péru, J.F. Berger, and P.F. Bortignon, Eur. Phys. Jour. A **26**, 25-32 (2005)

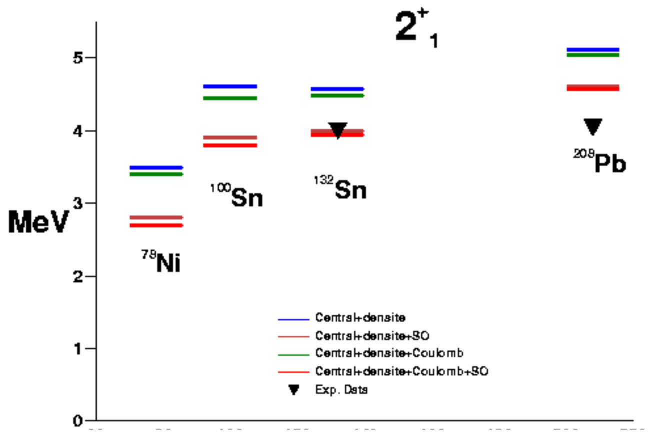
Monopole

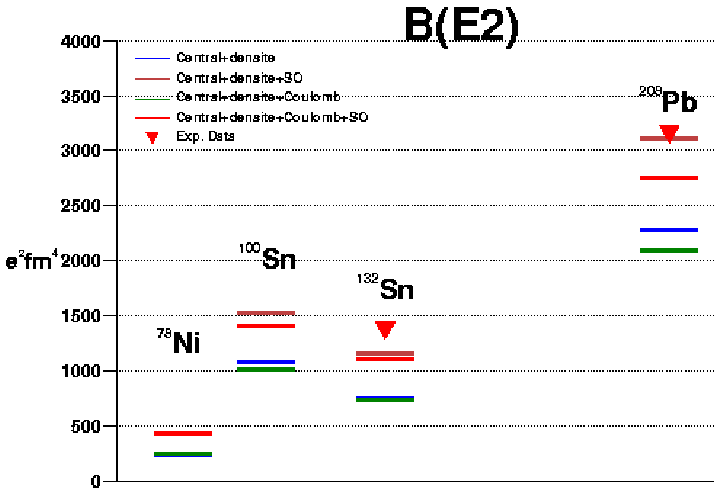


Dipole



Quadrupole





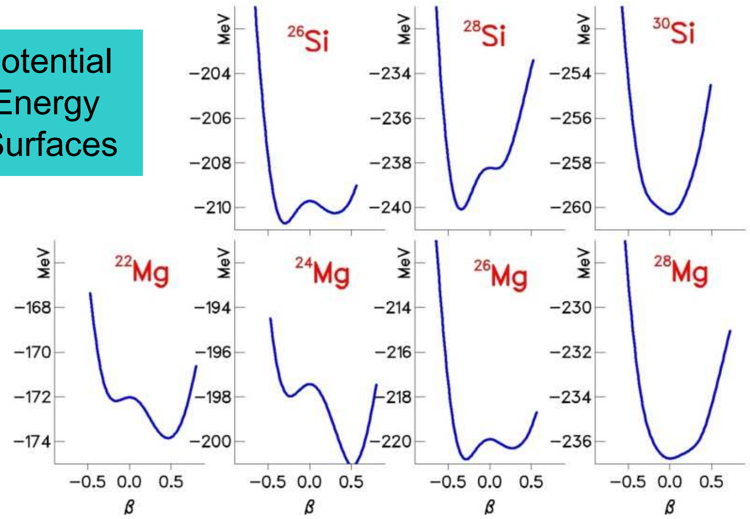
→ Such study have shown the role of the consistence between mean field and RPA matrix.

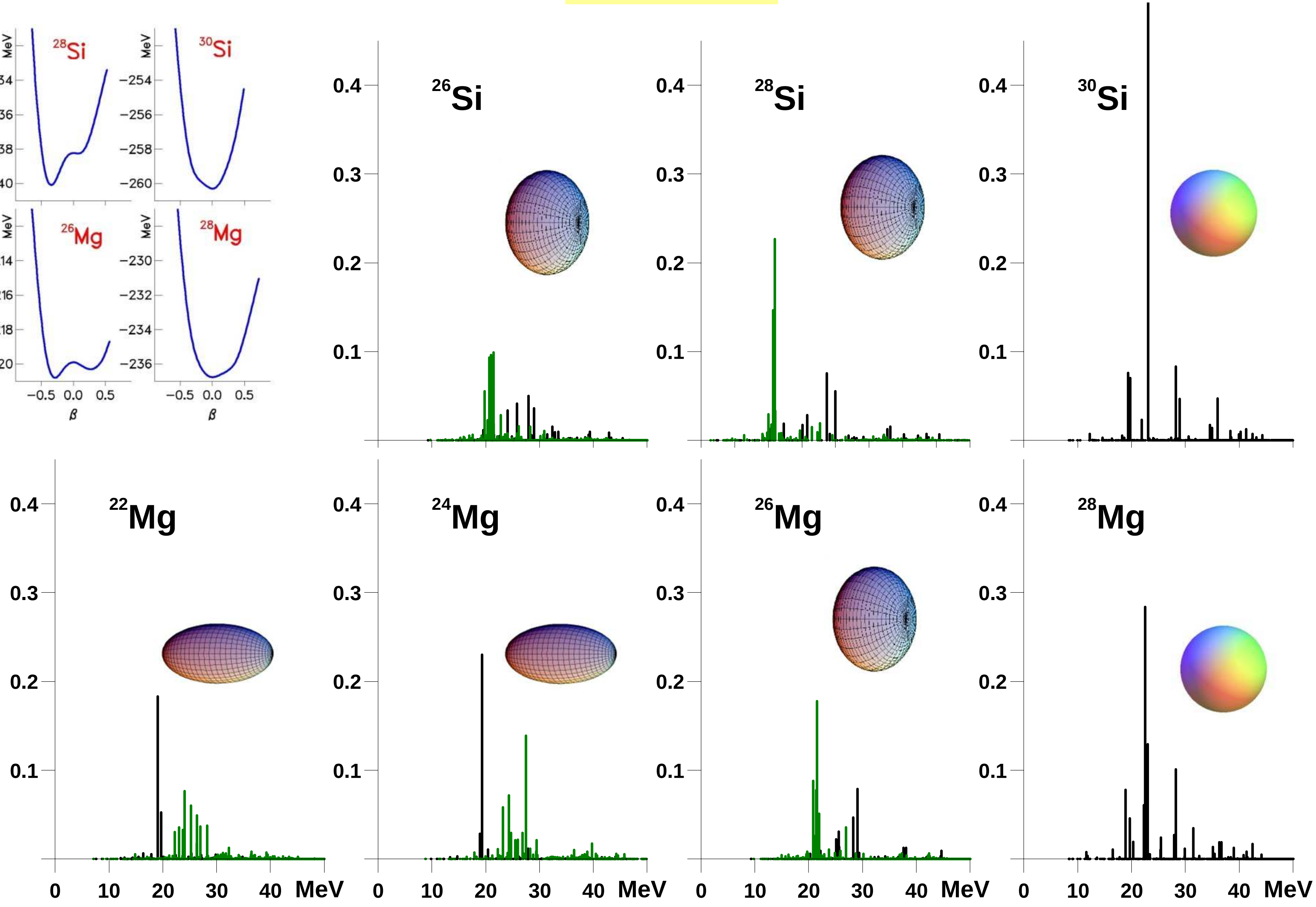
Approach limited to Spherical nuclei with no pairing

QRPA in axial symmetry :

IV Dipole $K^{\pi}=0^{-}$ $K^{\pi}=1^{-}$

Potential Energy Surfaces



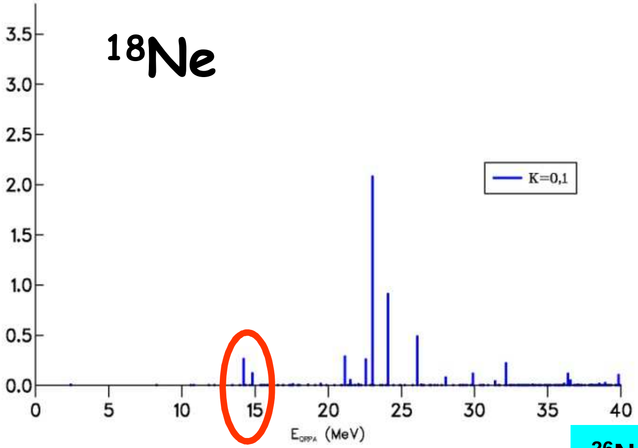


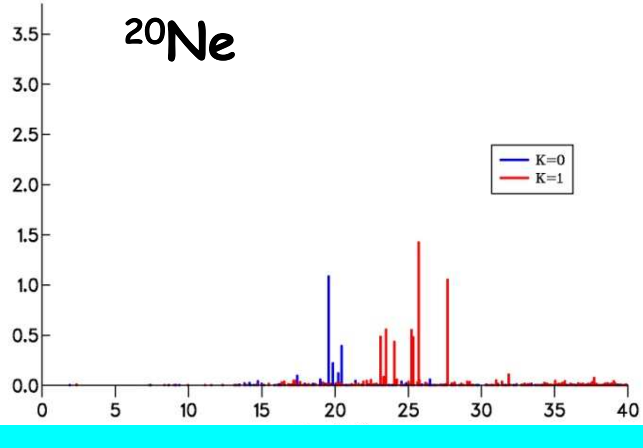
Role of deformation on giant resonances within the quasiparticle random-phase approximation and the Gogny force,
S. Péru and H. Goutte, Phys. Rev. C 77, 044313 (2008).

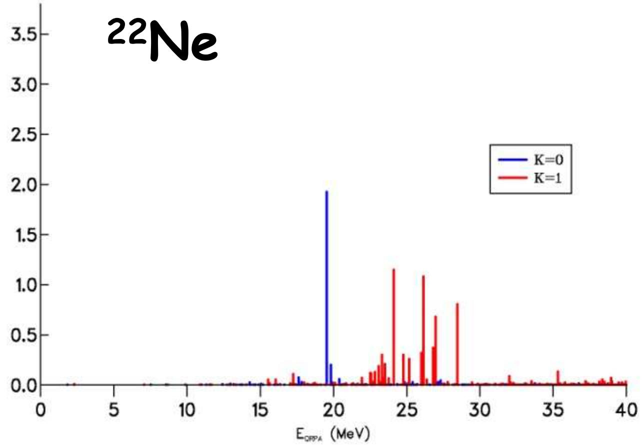
dipole response for Neon isotopes

Increasing neutron number

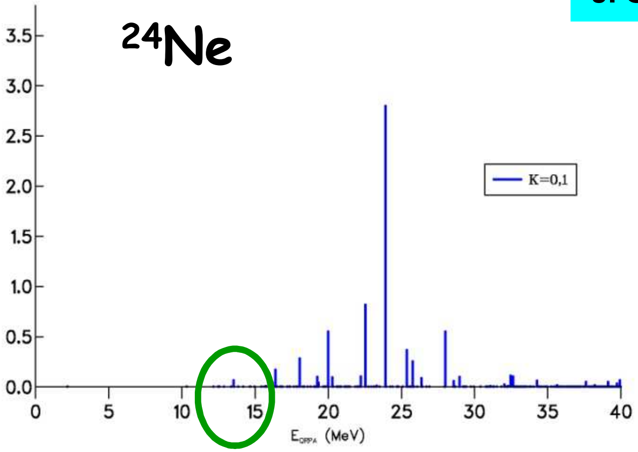
- Low energy dipole resonances and shift to low energies
- Increasing of fragmentation

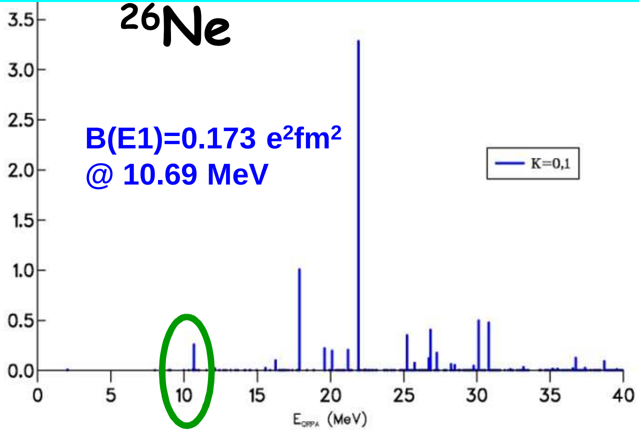


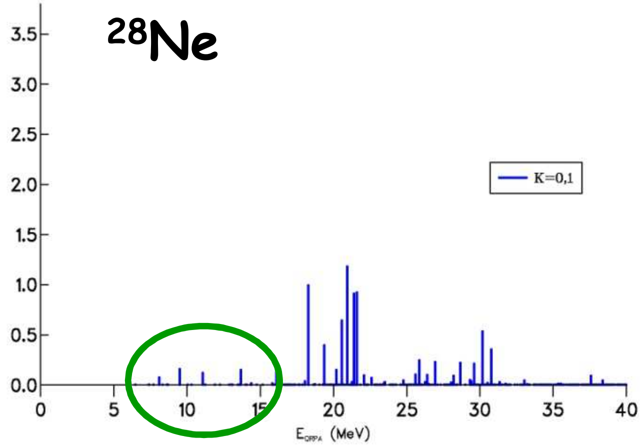




^{26}Ne
B(E1) = 0.49 ± 0.16 $e^2 fm^2$ %STRK = 4.9 ± 1.6 @ 9 MeV
J. Gibelin et al, PRL 101, 212503 (2008)



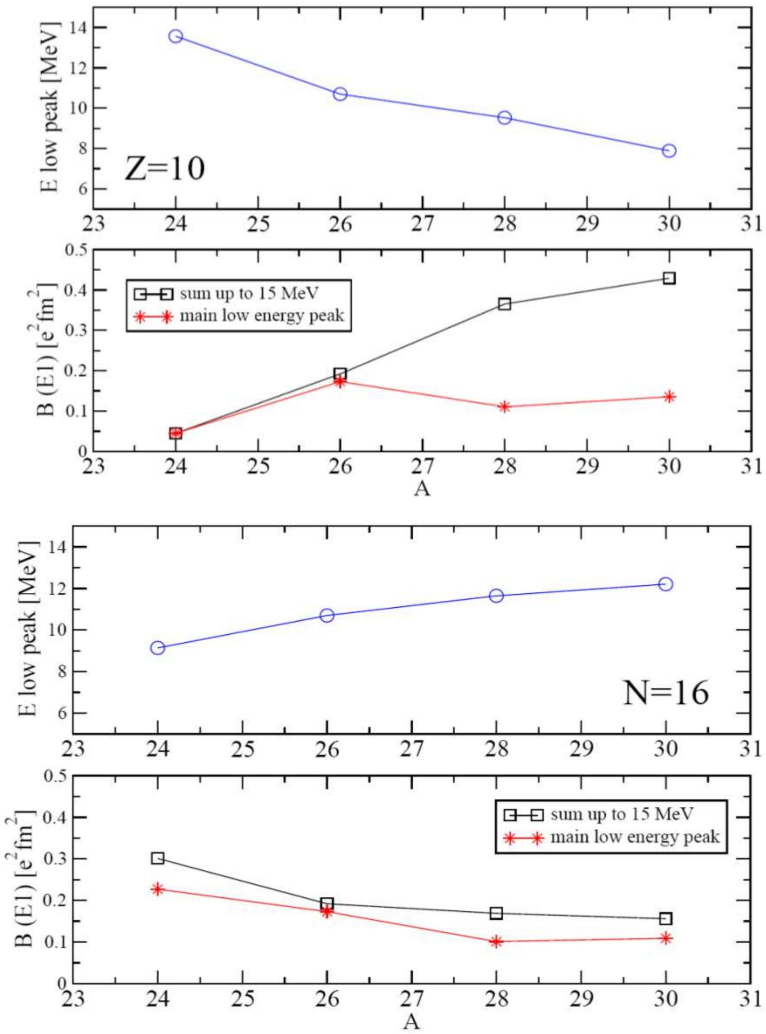


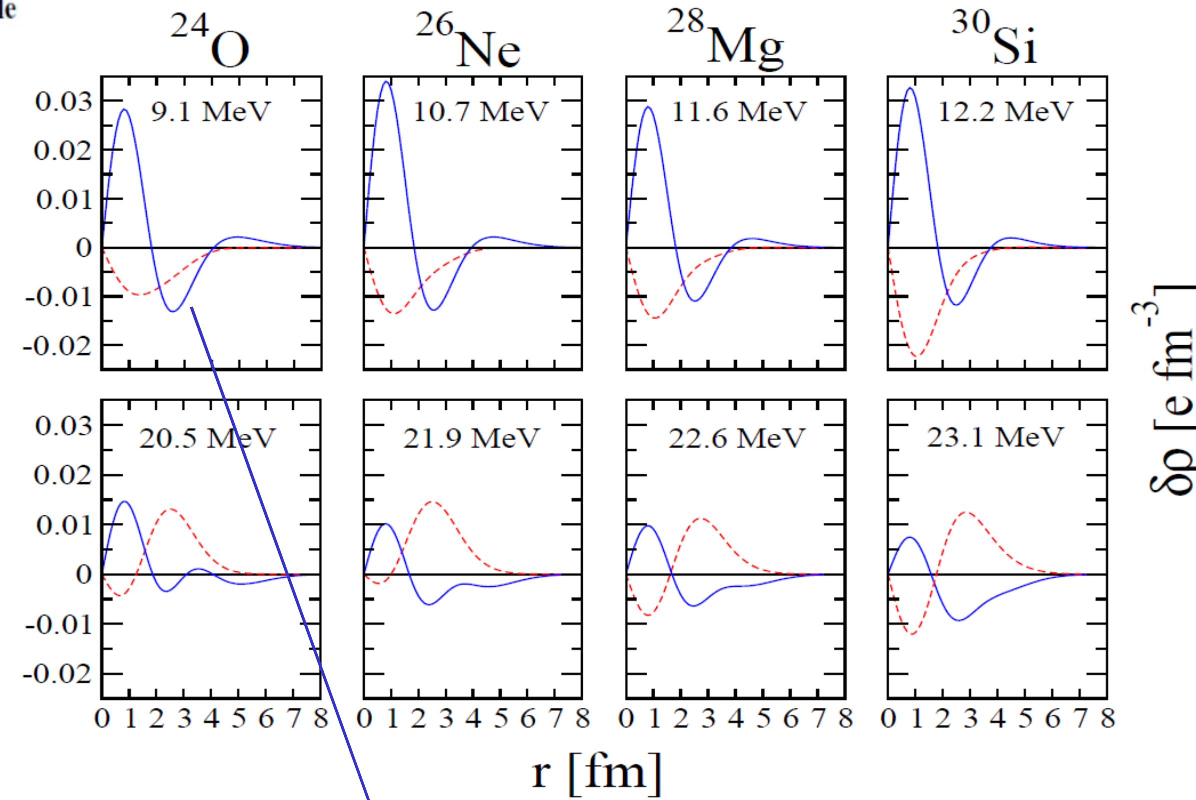


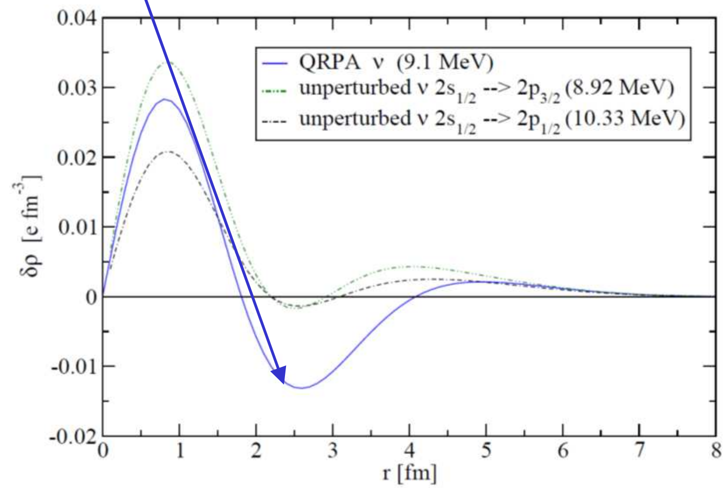
PHYSICAL REVIEW C 83, 034309 (2011)

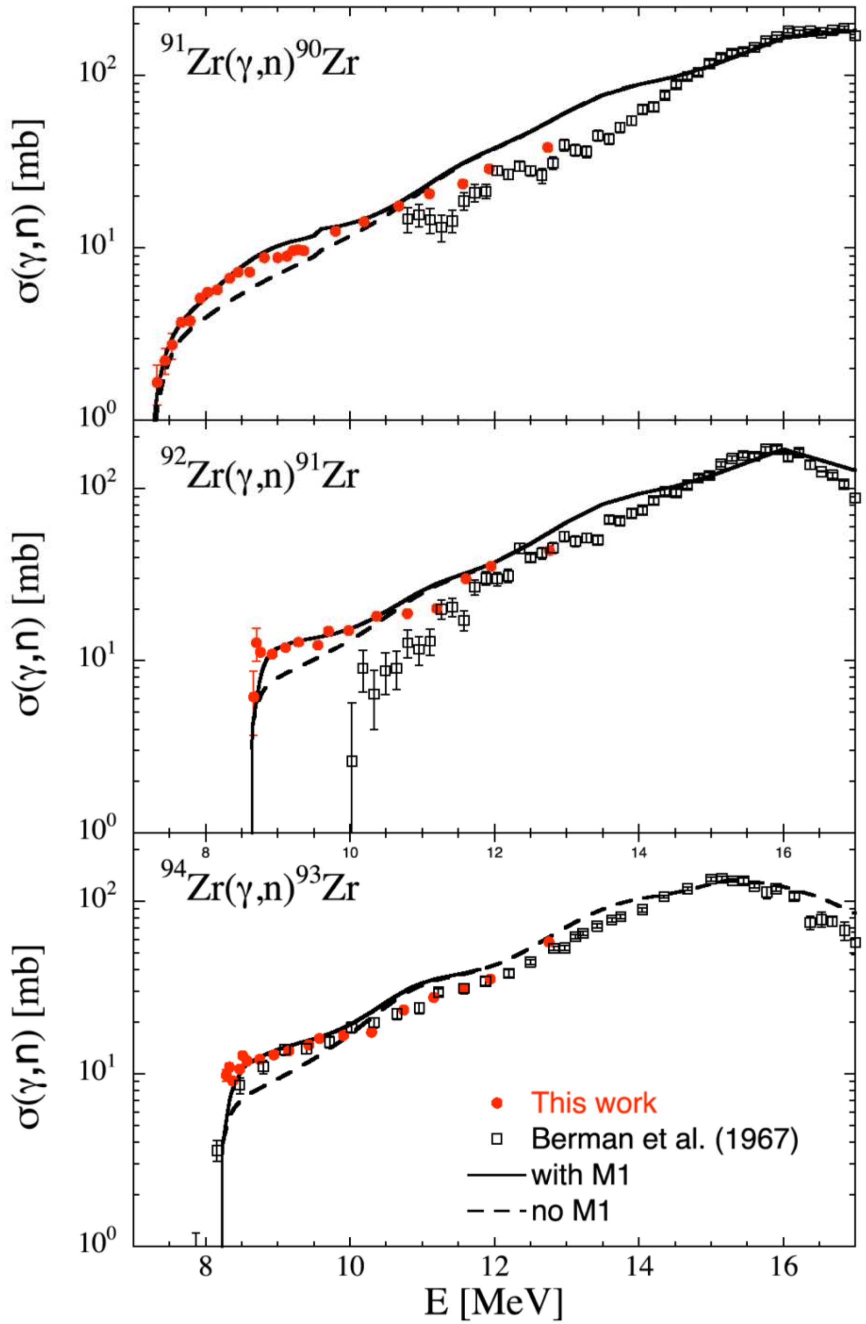
Low-energy dipole excitations in neon isotopes and $N = 16$ isotones within the quasiparticle random-phase approximation and the Gogny force

M. Martini, S. Péru, and M. Dupuis
CEA/DAM/DIF, F-91297 Arpajon, France









PRL 100, 162502 (2008) PHYSICAL REVIEW LETTERS week ending 25 APRIL 2008

$M1$ γ Strength for Zirconium Nuclei in the Photoneutron Channel

H. Utsunomiya,[1] S. Goriely,[2] T. Kondo,[1] T. Kaihori,[1] A. Makinaga,[1] S. Goko,[3] H. Akimune,[1] T. Yamagata,[1] H. Toyokawa,[4] T. Matsumoto,[4] H. Harano,[4] S. Hohara,[5] Y.-W. Lui,[6] S. Hilaire,[7] S. Péru,[7] and A. J. Koning[8]

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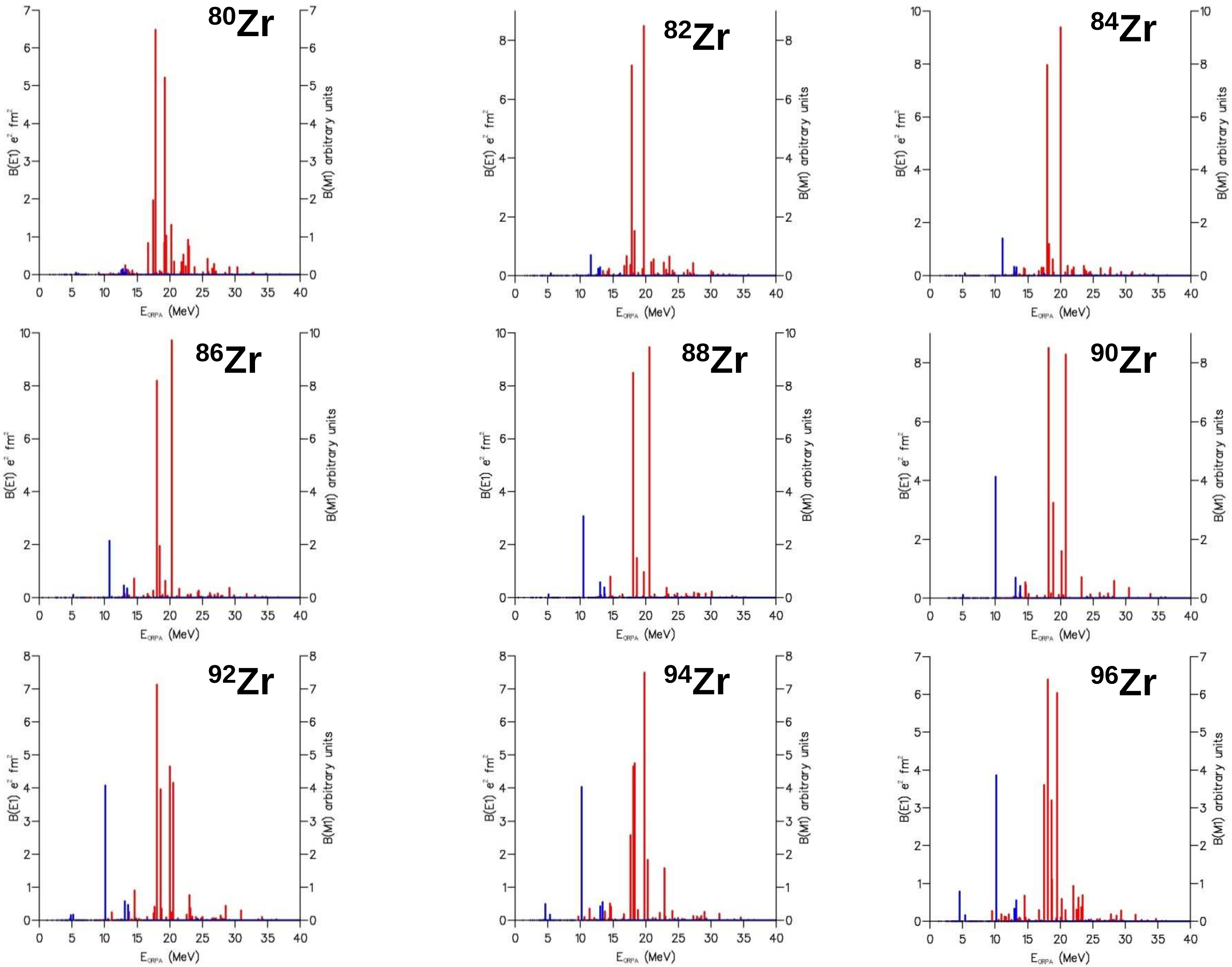
[2]*Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, Campus de la Plaine, CP-226, 1050 Brussels, Belgium*
[3]*Japan Atomic Energy Agency, Tokai-mura, Naka, Ibaraki 319-1195, Japan*
[4]*National Institute of Advanced Industrial Science and Technology, Tsukuba 305-8568, Japan*
[5]*Atomic Energy Research Institute, Kinki University, Kowakae 3-4-1, Osaka 577-8502, Japan*
[6]*Cyclotron Institute, Texas A&M University, College Station, Texas 77843, USA*
[7]*Département de Physique Théorique et Appliquée, Service de Physique Nucléaire, B.P. 12 - F-91680 Bruyères-le-Châtel, France*
[8]*Nuclear Research and Consultancy Group, P.O. Box 25, NL-1755 ZG Petten, The Netherlands*

(Received 30 November 2007; published 24 April 2008)

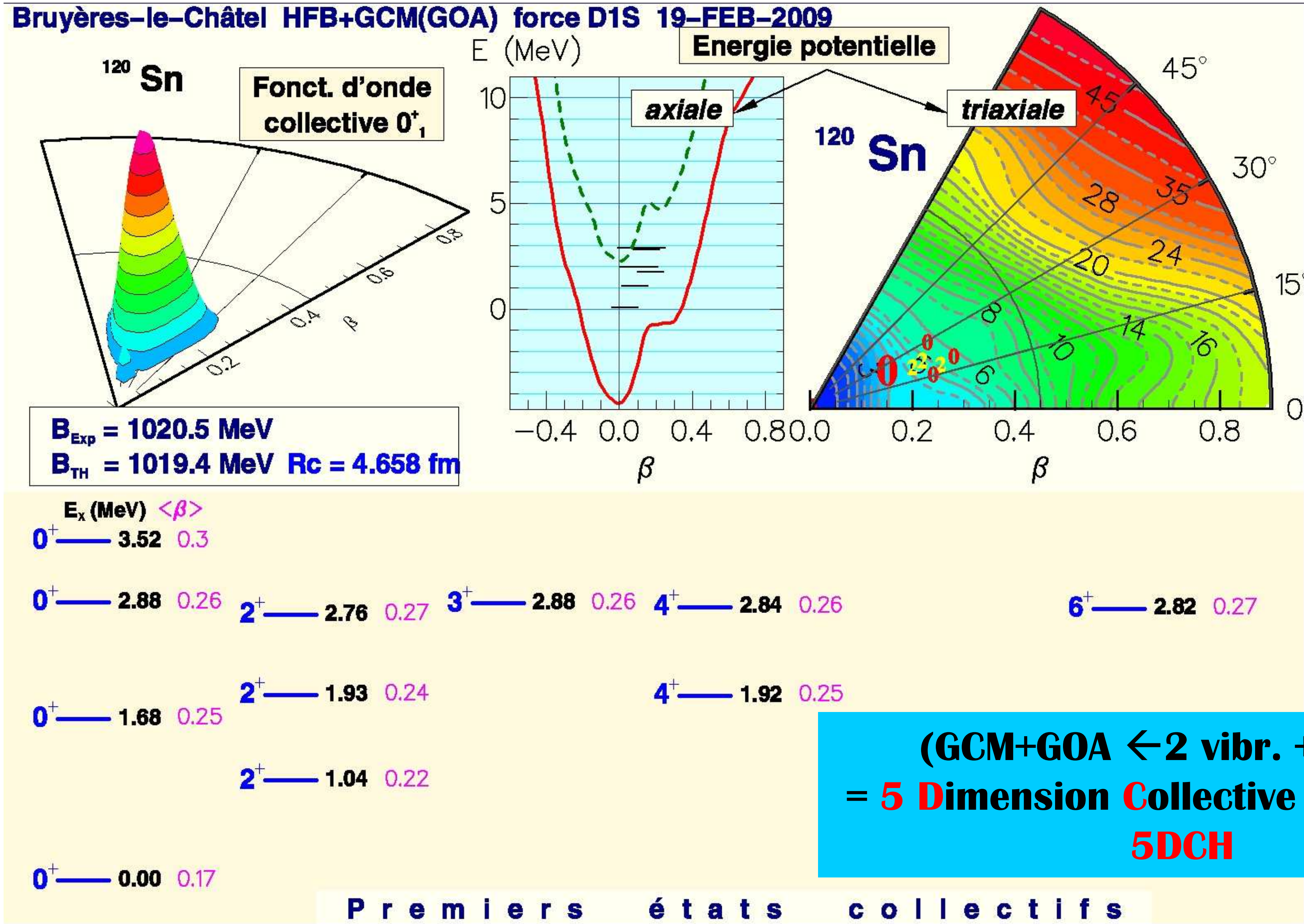
Dipole response for Zr isotopes :



B(E1)
B(M1)

S.Goriely,
H. Goutte,
S. Hilaire,
M. Martini,
S. Péru, …

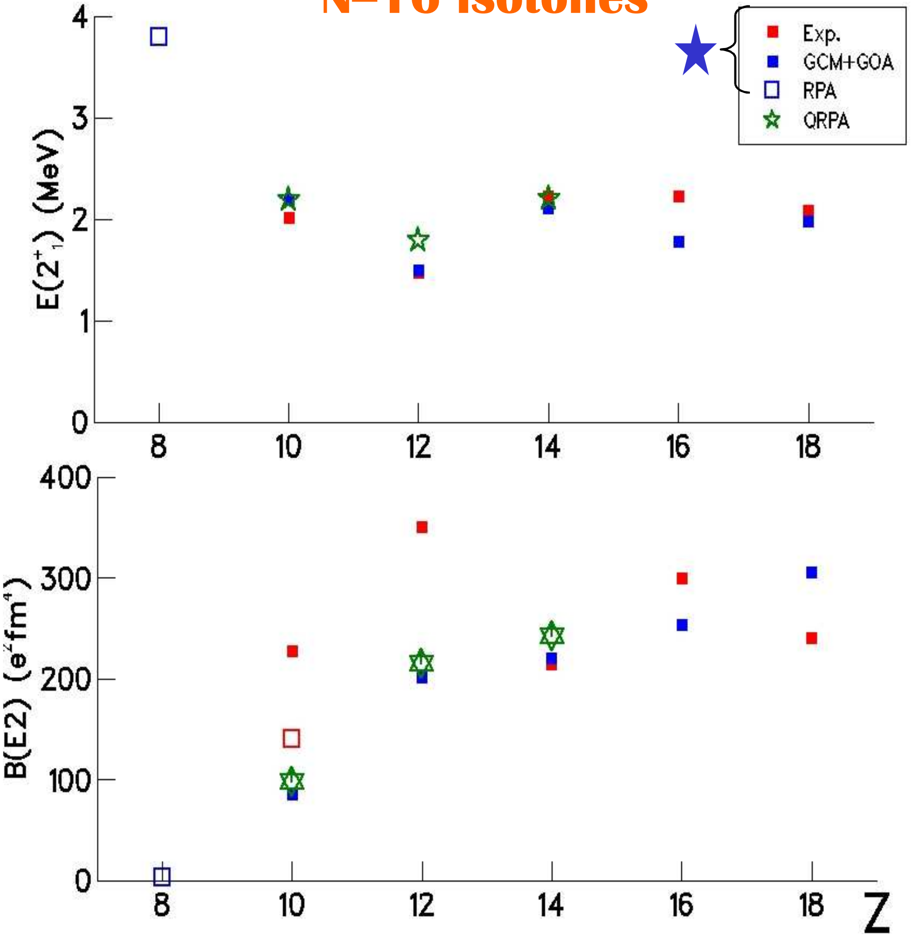
Beyond mean field … with "GCM"



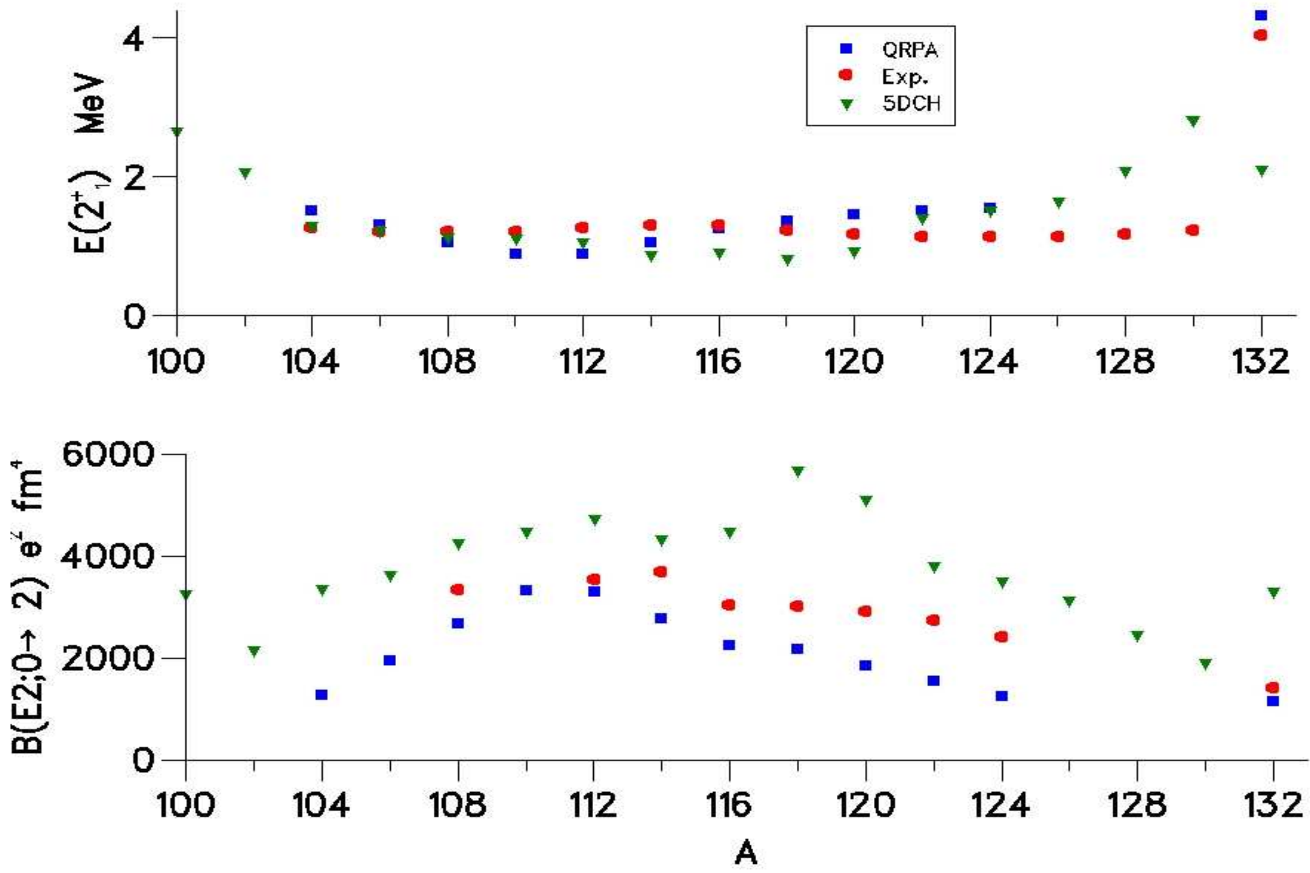
(GCM+GOA ←2 vibr. + 3 rot.)
= 5 Dimension Collective Hamiltonian
5DCH

HFB+QRPA / HFB+5DCH with the same interaction:

N=16 isotones

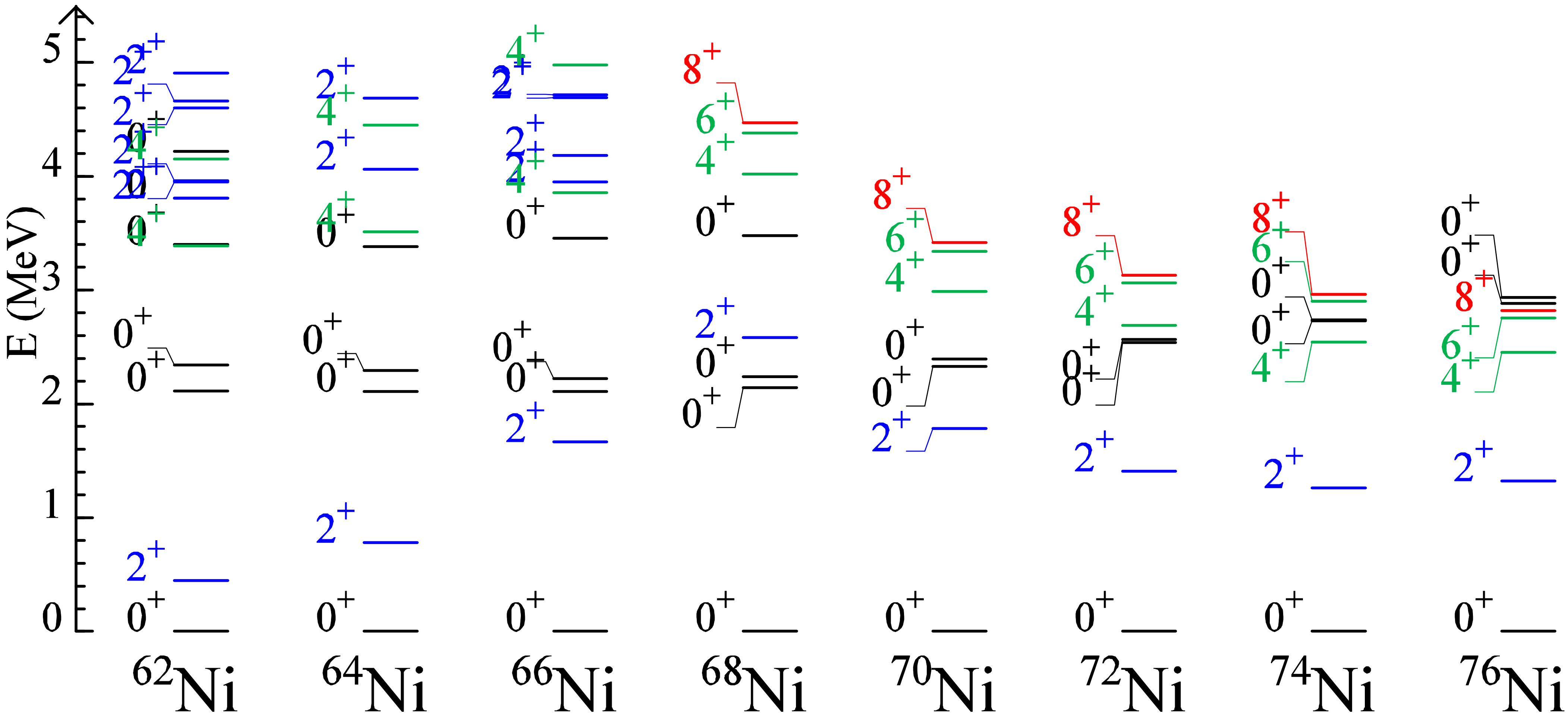


Sn isotopes



★ A. Obertelli, et al, Phys. Rev. C **71**, 024304 (2005)

Spectroscopy in Ni isotopes within QRPA



L. Gaudefroy & S. Péru

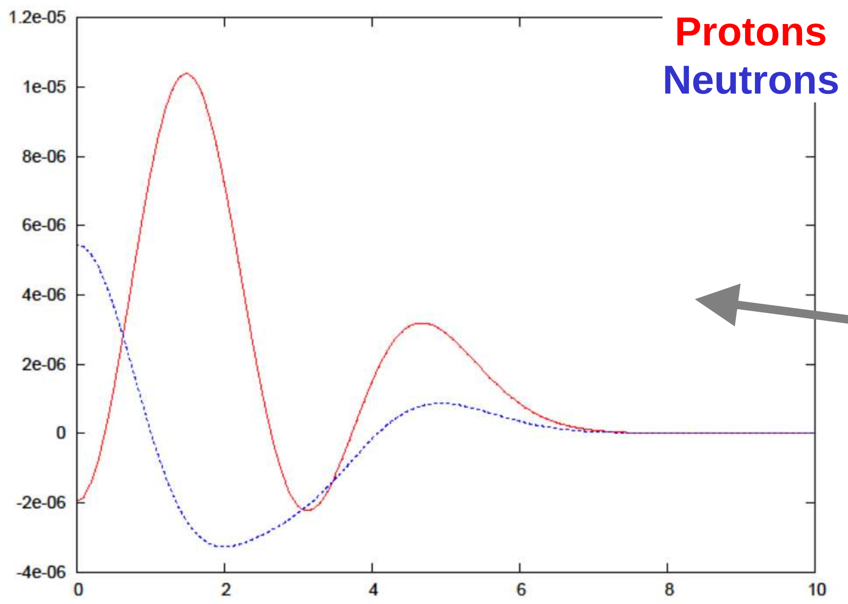
PHYSICAL REVIEW C 85, 031301(R) (2012)

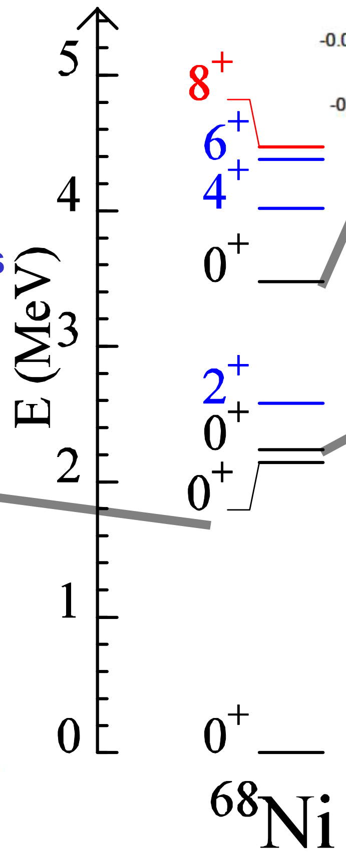
Discovery of a new isomeric state in ^{68}Ni: Evidence for a highly deformed proton intruder state

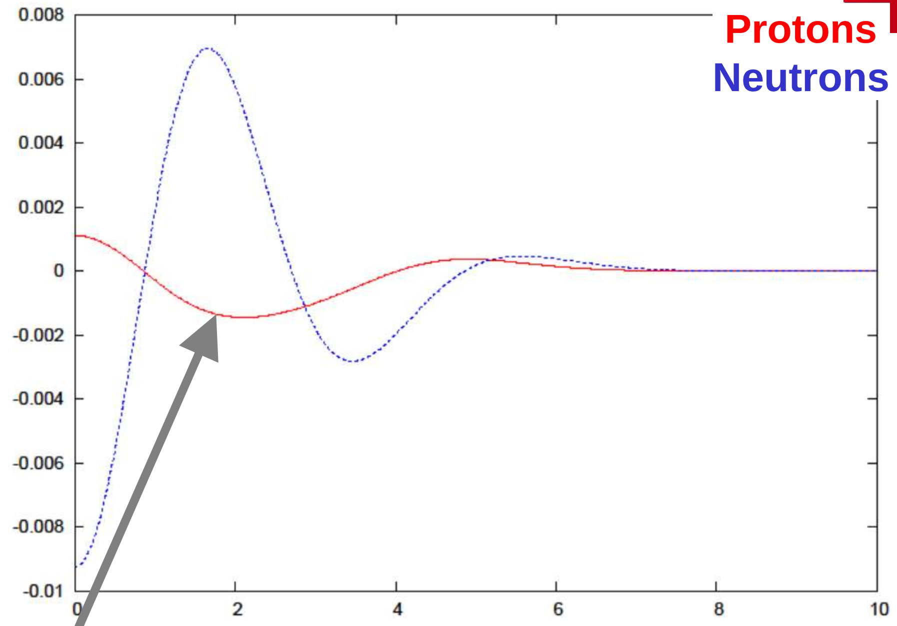
A. Dijon,[1] E. Clément,[1] G. de France,[1] G. de Angelis,[2] G. Duchêne,[3] J. Dudouet,[1] S. Franchoo,[4] A. Gadea,[5] A. Gottardo,[2,6] T. Hüyük,[5] B. Jacquot,[1] A. Kusoglu,[7] D. Lebhertz,[1] G. Lehaut,[8] M. Martini,[9] D. R. Napoli,[2] F. Nowacki,[3] S. Péru,[9] A. Poves,[11] F. Recchia,[6] N. Redon,[8] E. Sahin,[2] C. Schmitt,[1] M. Sferrazza,[11] K. Sieja,[3] O. Stezowski,[8] J. J. Valiente-Dobón,[2] A. Vancraeyenest,[8] and Y. Zheng[1,12]

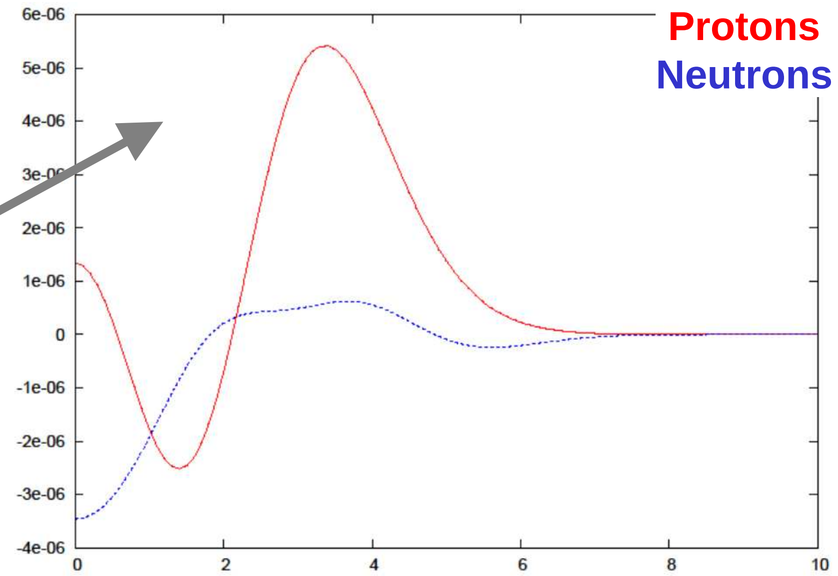
0^+ states in ^{68}Ni within QRPA

Transition densities









M. Martini, S. Péru …

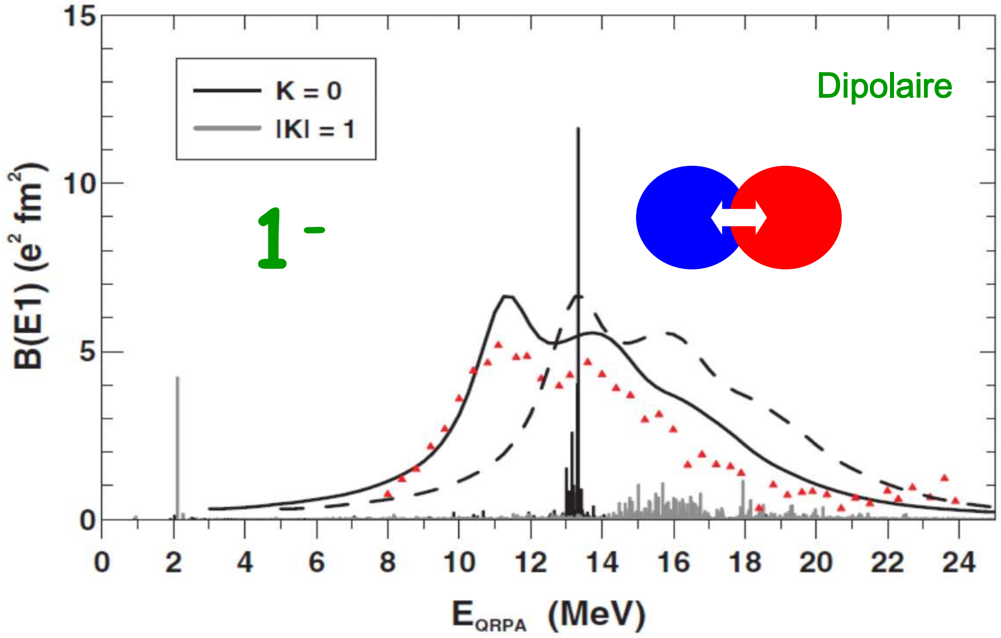
Multipolar response for ^{238}U

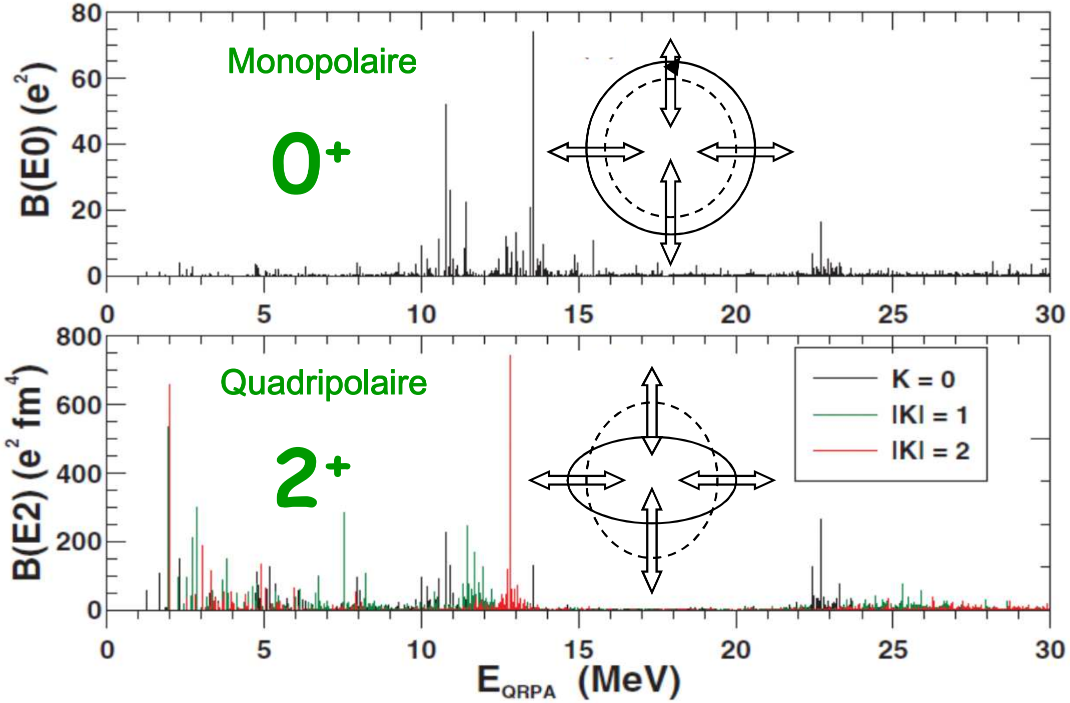
PHYSICAL REVIEW C **83**, 014314 (2011)

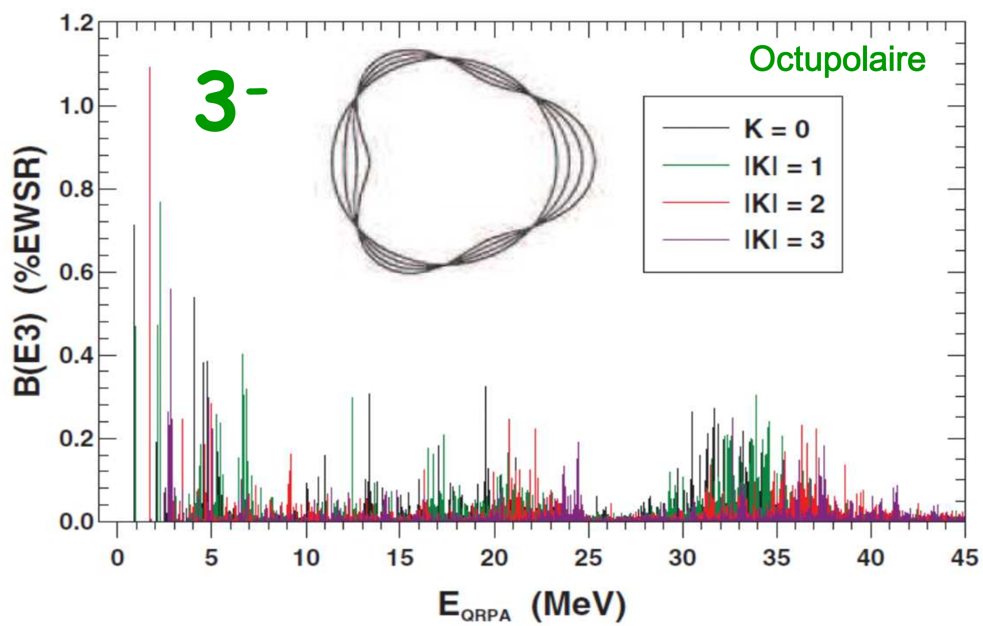
Giant resonances in ^{238}U within the quasiparticle random-phase approximation with the Gogny force

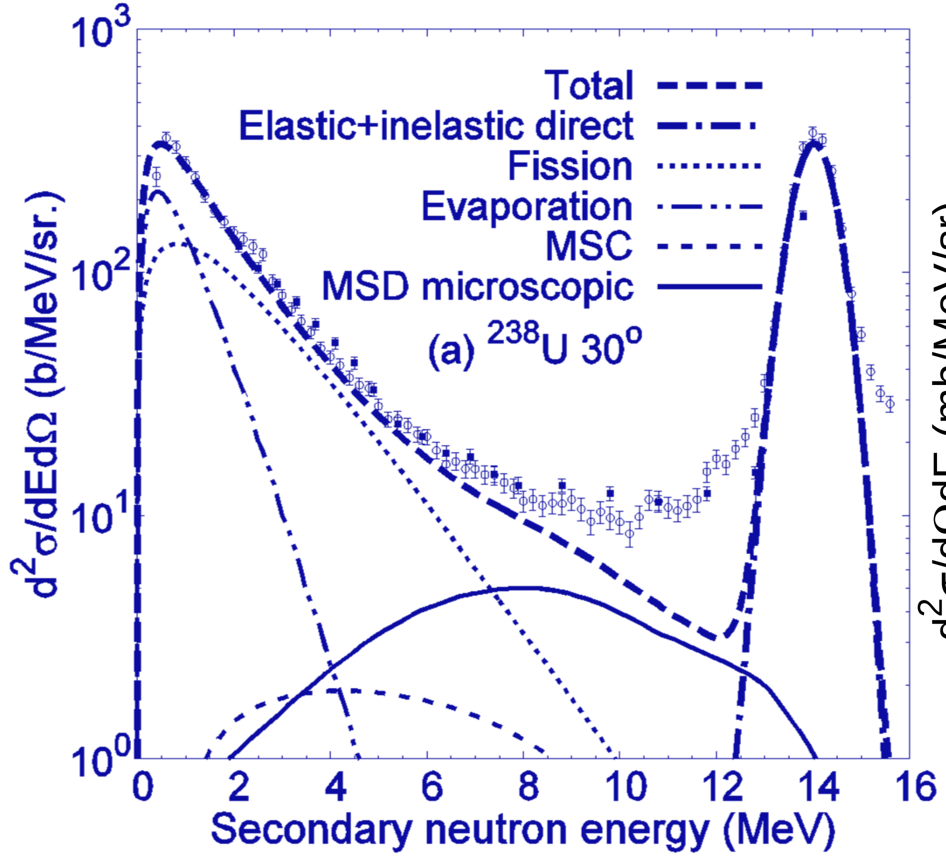
S. Péru,[1,*] G. Gosselin,[1] M. Martini,[1] M. Dupuis,[1] S. Hilaire,[1] and J.-C. Devaux[2]
[1]*CEA/DAM/DIF, F-91297 Arpajon, France*
[2]*ENSIIE, 1 square de la résistance, F-91025 Evry Cedex, France*
(Received 29 October 2010; published 27 January 2011)

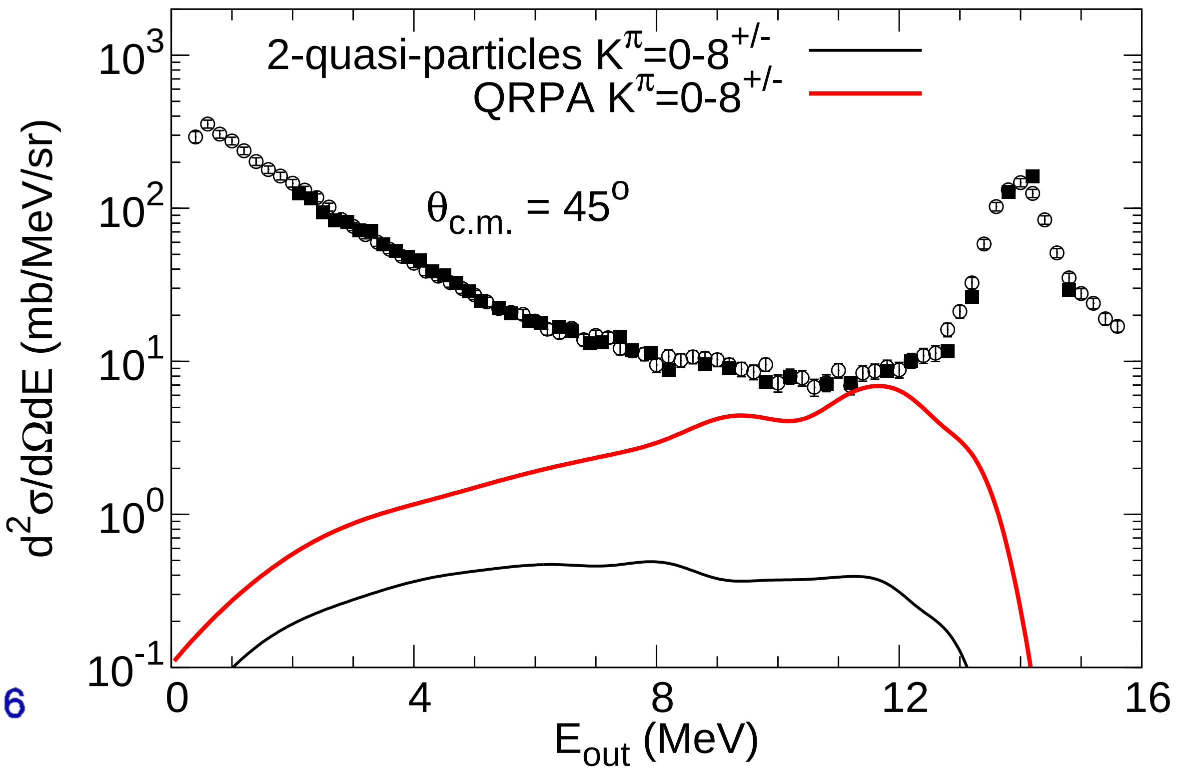
More than 716800 hours (~82 years) of computing time spread over 256 and 512 proc.











Comparison between experimental data (circles) and one-step contributions (full curves) to the double-differential cross sections for 14.1 MeV neutron on 238 U (a,c).

M. Dupuis et al,
13th International Conference on Nuclear Reaction Mechanisms, Varenna, june 11-15, 2012.

M. Dupuis et al,
Proceedings of the Second International Workshop on Nuclear Compound Reactions and Related Topics, (2010).

… beyond the nuclear structure :

Test of QRPA and 5DCH (GCM) wave functions in proton inelastic scattering…

^{36}S

HFB+5DCH — E (2^+_1) = 2.34 MeV — B(E2) = 375 e^2fm^4

HFB+QRPA — E (2^+_1) = 3.29 MeV — B(E2) = 139.7 e^2fm^4

Exp — E (2^+_1) = 3.29 MeV — B(E2) = 100 e^2fm^4