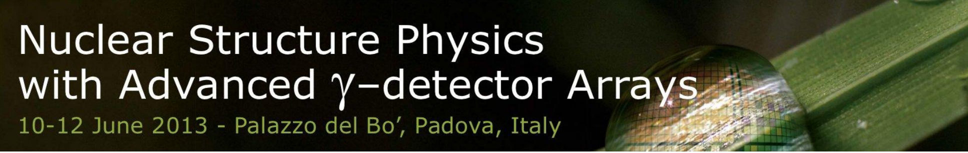


Nuclear Structure Physics
with Advanced γ–detector Arrays
10-12 June 2013 - Palazzo del Bo', Padova, Italy

Collectivity in neutron-rich Co and Mn isotopes going towards N=40

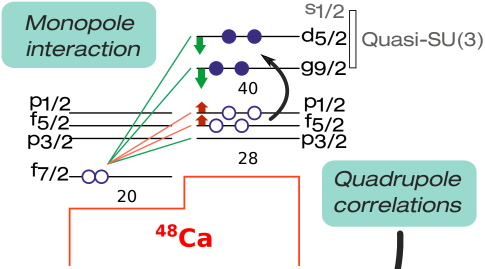
Victor Modamio
Laboratori Nazionali di Legnaro, INFN

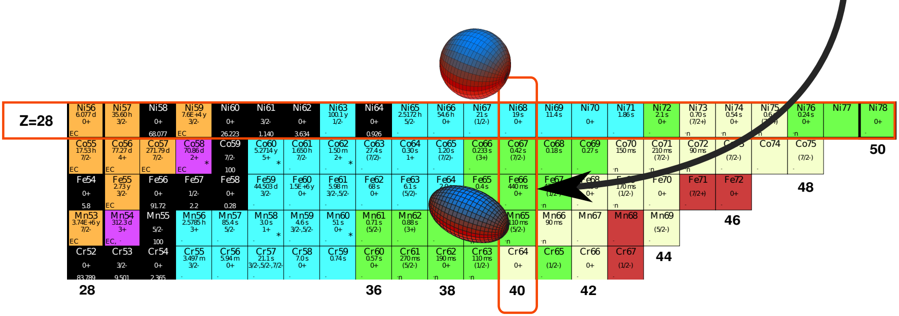
AGATA
ADVANCED GAMMA
TRACKING ARRAY

INFN

Deformation below *N=40* ^{68}Ni

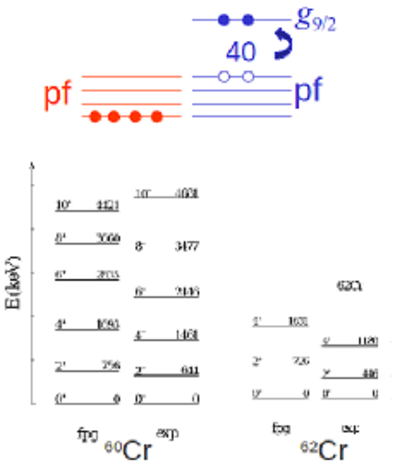
Quadrupole deformation can be generated by using a quadrupole force with the central field in the subspace spanned by a sequence of Δj = 2 orbits that come lowest by the spin-orbit splitting, representing this relevant subspace a quasi-SU3.



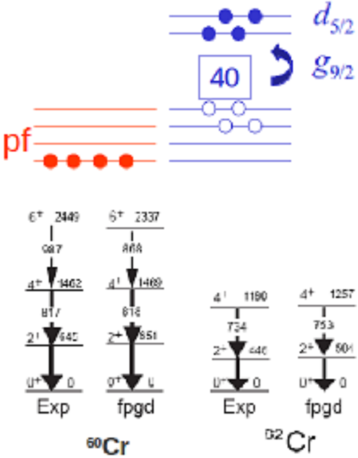


	N=28								N=36		N=38		N=40		N=42								N=50
Z=28	Ni56 6.077 d 0+ EC	Ni57 35.60 h 3/2-	Ni58 0+ 68.077	Ni59 7.6E+4 y 3/2- EC	Ni60 0+ 26.223	Ni61 3/2- 1.140	Ni62 0+ 3.634	Ni63 100.1 y 1/2- -	Ni64 0+ 0.926	Ni65 2.5172 h 5/2- -	Ni66 54.6 h 0+ -	Ni67 21 s (1/2-) -	Ni68 19 s 0+ -	Ni69 11.4 s -	Ni70 0+	Ni71 1.86 s -	Ni72 2.1 s 0+ -	Ni73 0.70 s (7/2+) -n	Ni74 0.54 s 0+ -n	Ni75 0.6	Ni76 0.24 s 0+ -n	Ni77	Ni78 0+ -
	Co55 17.53 h 7/2- EC	Co56 77.27 d 4+ EC	Co57 271.79 d 7/2- EC	Co58 70.86 d 2+ * EC	Co59 7/2- 100	Co60 5.2714 y 5+ *	Co61 1.650 h 7/2- -	Co62 1.50 m 2+ * -	Co63 27.4 s (7/2)- -	Co64 0.30 s 1+ -	Co65 1.20 s (7/2)- -	Co66 0.233 s (3+) -	Co67 0.42 s (7/2-) -	Co68 0.18 s -	Co69 0.27 s -	Co70 150 ms -n	Co71 210 ms (7/2-) -n	Co72 90 ms -n	(7/2-) -	Co74 -	Co75 (7/2-) -		
	Fe54 0+ 5.8	Fe55 2.73 y 3/2- EC	Fe56 0+ 91.72	Fe57 1/2- 2.2	Fe58 0+ 0.28	Fe59 44.503 d 3/2- -	Fe60 1.5E+6 y 0+ -	Fe61 5.98 m 3/2-,5/2- -	Fe62 68 s 0+ -	Fe63 6.1 s (5/2)- -	Fe64 2.0 s	Fe65 0.4 s	Fe66 440 ms 0+ -	Fe67 -n	0+ -	170 ms (1/2-) -n	Fe70 0+ -	Fe71 (7/2+) -	Fe72 0+ -				
	Mn53 3.74E+6 y 7/2- EC	Mn54 312.3 d 3+ EC, -	Mn55 5/2- 100	Mn56 2.5785 h 3+ -	Mn57 85.4 s 5/2- -	Mn58 3.0 s 1+ * -	Mn59 4.6 s 3/2-,5/2- -	Mn60 51 s 0+ * -	Mn61 0.71 s (5/2-) -	Mn62 0.88 s (3+) -	-		Mn65 110 ms (5/2-) -n	Mn66 90 ms -n	Mn67 -	Mn68 -	Mn69 (5/2-) -						
	Cr52 0+ 83.789	Cr53 3/2- 9.501	Cr54 0+ 2.365	Cr55 3.497 m 3/2- -	Cr56 5.94 m 0+ -	Cr57 21.1 s 3/2-,5/2-,7/2- -	Cr58 7.0 s 0+ -	Cr59 0.74 s -	Cr60 0.57 s 0+ -	Cr61 270 ms (5/2-) -n	Cr62 190 ms 0+ -n	Cr63 110 ms (1/2-) -n	Cr64 0+	Cr65 (1/2-) -	Cr66 0+ -	Cr67 (1/2-) -							
	28								36		38		40		42		44		46		48		50

Role of the orbitals $g_{9/2}$ and $d_{5/2}$



SM calcs. with *fpg* valence space does not reproduce collectivity



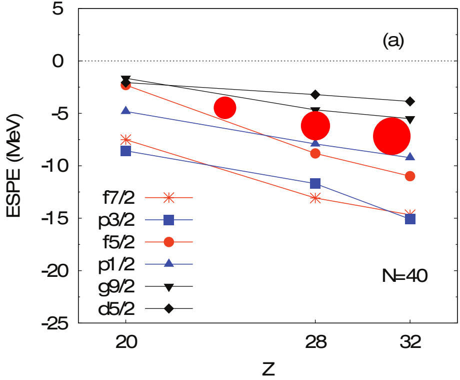
Inclusion of orbital $d_{5/2}$ above N=50 does!

S. Lenzi et al. LNL Ann. Rep. 2008
S. Lenzi, F. Nowacki, A. Poves and K. Sieja
PRC82, 054301 (2010)

Role of the orbitals $g_{9/2}$ and $d_{5/2}$

Evolution of neutron shell gap
when removing protons

N=40



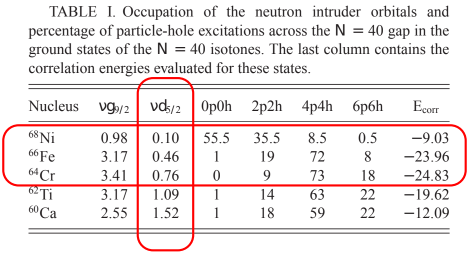
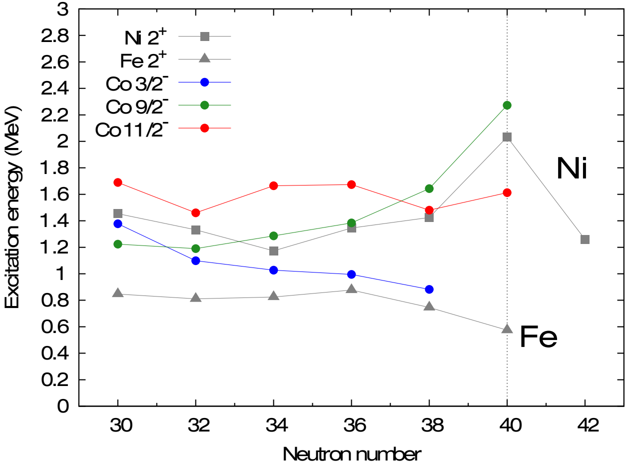


TABLE I. Occupation of the neutron intruder orbitals and percentage of particle-hole excitations across the N = 40 gap in the ground states of the N = 40 isotones. The last column contains the correlation energies evaluated for these states.

Nucleus	$\nu g_{9/2}$	$\nu d_{5/2}$	0p0h	2p2h	4p4h	6p6h	E_{corr}
^{68}Ni	0.98	0.10	55.5	35.5	8.5	0.5	−9.03
^{66}Fe	3.17	0.46	1	19	72	8	−23.96
^{64}Cr	3.41	0.76	0	9	73	18	−24.83
^{62}Ti	3.17	1.09	1	14	63	22	−19.62
^{60}Ca	2.55	1.52	1	18	59	22	−12.09

S. Lenzi, F. Nowacki, A. Poves and K. Sieja
PRC82, 054301 (2010)

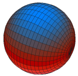
Cobalt chain



A. Dijon et al. PRC83, 064321 (2011)
F. Recchia et al. PRC85, 064305 (2012)

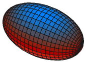
I = 11/2⁻ and 9/2⁻

$$\pi(f_{7/2})^{-1} \otimes 2^+ \,\mathrm{Ni}$$



I = 3/2⁻

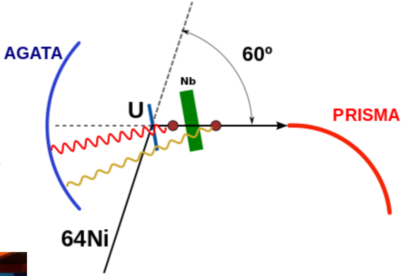
$$\pi(f_{7/2}) \otimes 2^+ \,\mathrm{Fe}$$



Multinucleon-transfer reaction

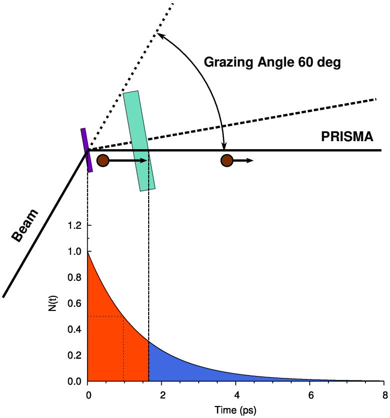
Plunger experiment in the LNL AGATA Campaign (June 2010)

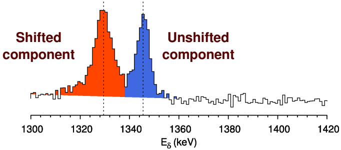
Multi-nucleon transfer reaction
^{64}Ni + U (Grazing angle 60º)
Beam: 460 MeV (~2.5 pnA)
Target: U 1.35 mg/cm2
Degrader: Nb 4.13 mg/cm2
3 plunger distances ranging 1-5 ps flight time



AGATA (4 clusters)
PRISMA mass spectrometer
Köln Plunger

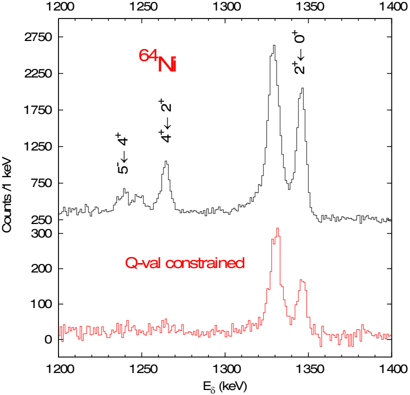
RDDS Method. Plunger

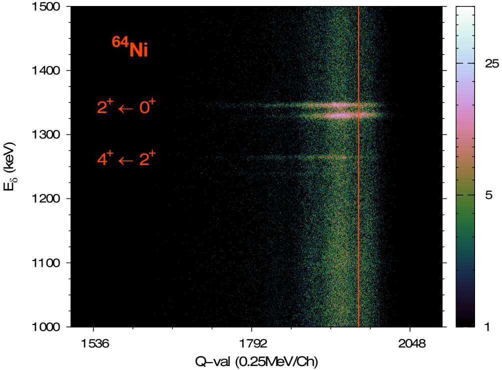




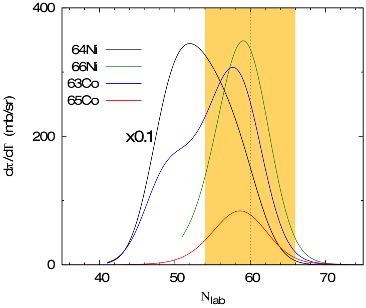
AGATA backward angles

Indirect feeding

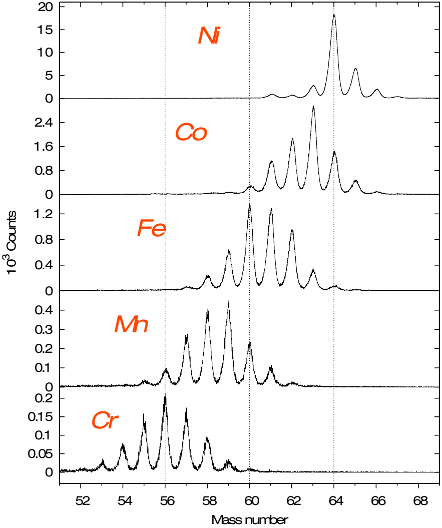




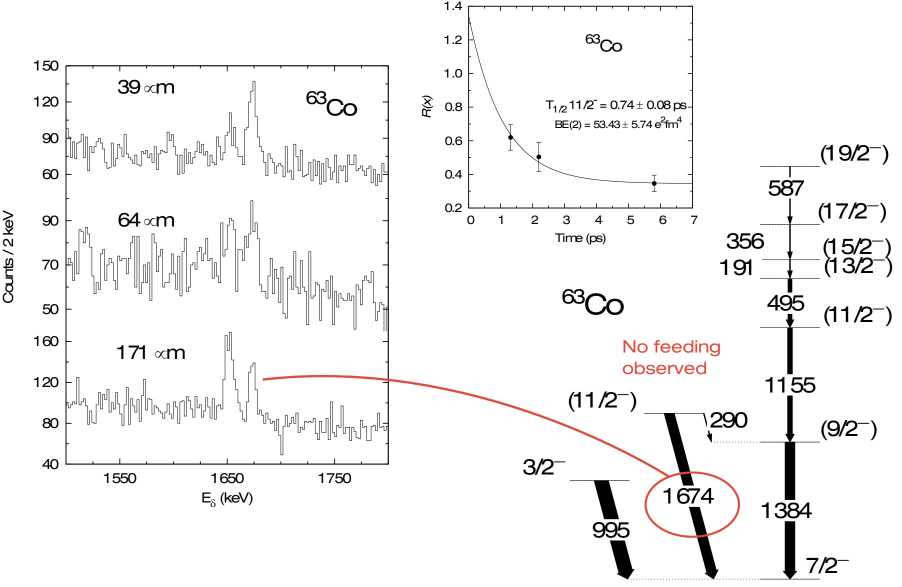
Yieldings



Differential cross-section calculations with *GRAZING CODE*

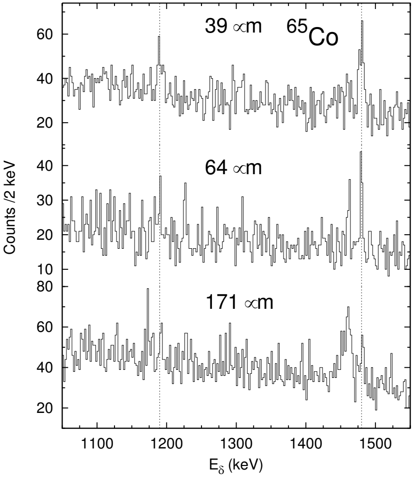


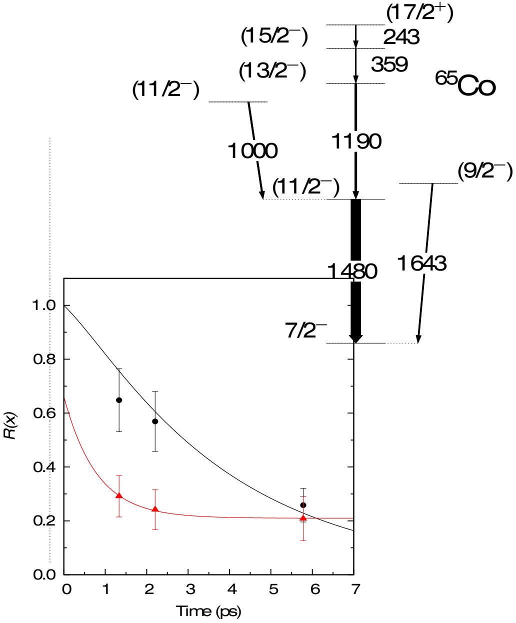
Results on ^{63}Co



No feeding observed

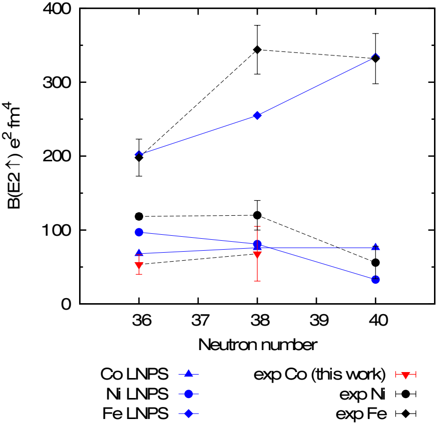
Results on ^{65}Co



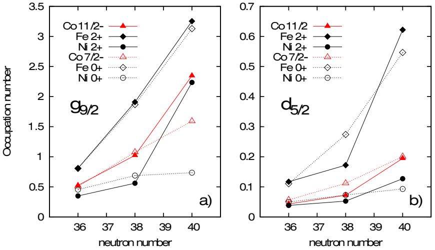


Nature of the state (11/2$^-$) in Co isotopes

B(E2) values

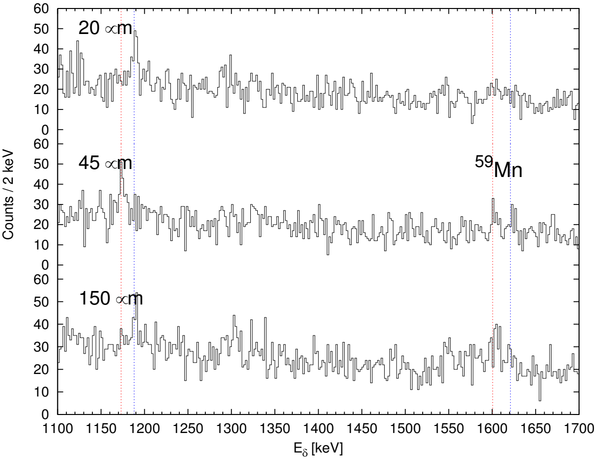


Neutron occupation number



Mn isotopes

^{59}Mn spectra for preliminary measurements of lifetimes in the 3 proton channel.

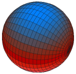


M. Siciliano

Conclusions

Lifetimes for the low lying states $11/2^-$ in ^{63,65}Co have been measured for first time.

Deduced B(E2) values for these states follow the stregh values of the Ni isotones, indicating that the (11/2-) states in Co present a configuration $\pi(f_{7/2})^{-1} \otimes 2^+ \mathrm{Ni}$



Large-scale shell-model calculations predict accurately the *B*(E2) values in Co, Fe and Ni isotopes, showing a strongh dependence with the occupation of both the $g_{9/2}$ and $d_{5/2}$ neutron orbitals in the wavefunction.

The theoretical *B*(E2) value predicted for *N=40* ^{67}Co is larger than the *B*(E2) value for the isotone ^{68}Ni, pointing to a weakening of the *N=40* subshell gap just by removing one proton.

Collaborators

J.J.Valiente-Dobón[1], D.Mengoni[2,9], S.Lenzi[2], S.Lunardi[2], A.Gadea[4], D.Bazzaco[2], A.Bürger[3], A.Algora[4], L.Corradi[1], G.de Angelis[1], R.Depalo[2], A.Dewald[5], M.N.Erduran[6], E.Farnea[2], E.Fioretto[1], K.Geibel[5], A.Gottardo[1], M.Hackstein[5], T.Hüyük[4], R.Kempley[7], B.Melon[8], R.Menegazzo[2], C.Michelagnoli[2], O.Möller[10], G.Montagnoli[2], D.Montanari[1], A.Nannini[8], D.R.Napoli[1], P.Reiter[5], F.Recchia[2], W.Rother[5], P.A.Söderström[11], E.Sahin[1], F.Scarlassara[2], A.M.Stefanini[1], S.Szilner[12] and C.Ur[2].

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