Lifetime measurements on ^{63,65}Co

Víctor Modamio

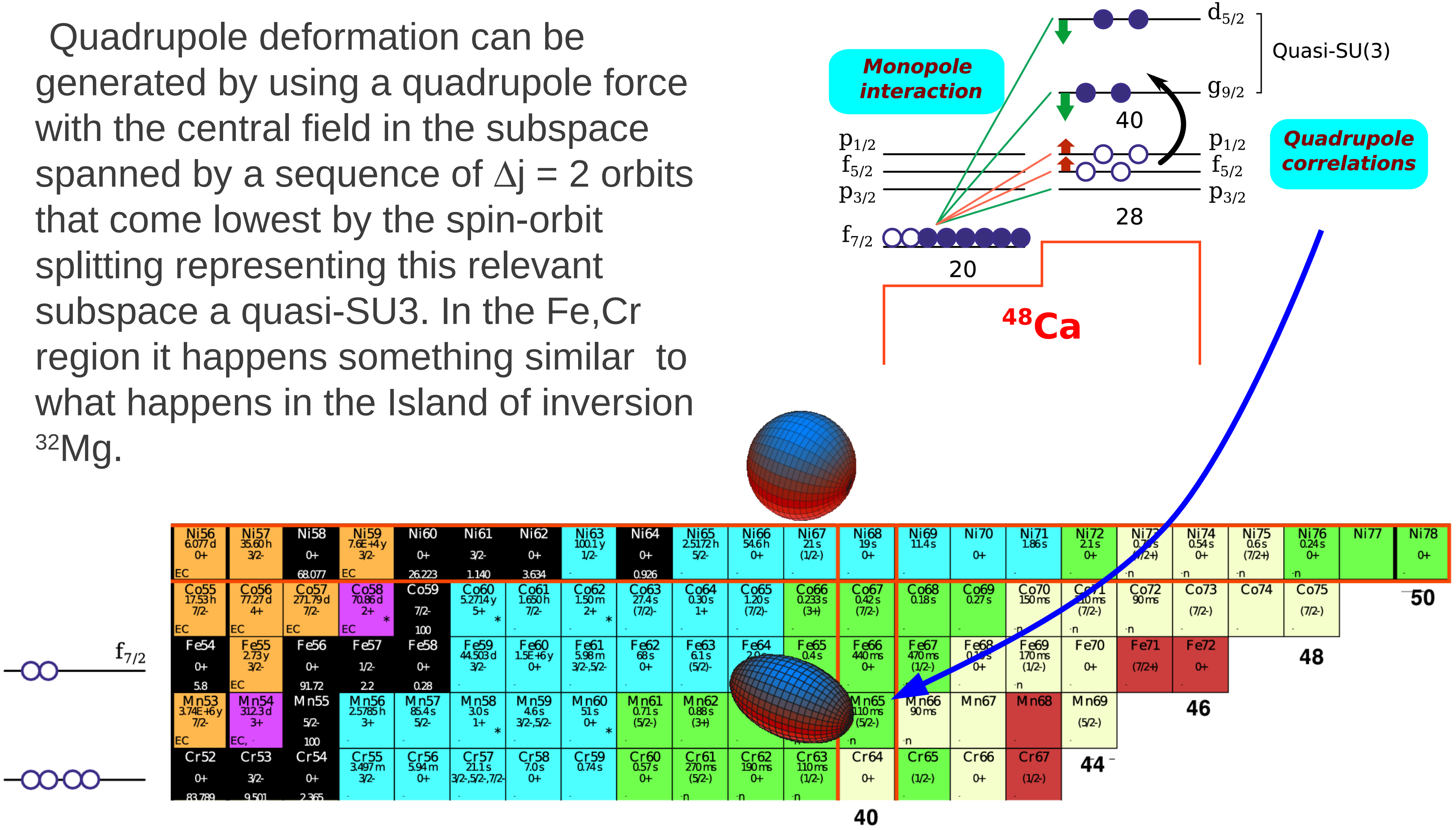
Laboratori Nazionali di Legnaro, INFN

Contents

- Motivation: *Shell effects close to* ^{68}*Ni*
- Experiment: *Plunger+AGATA+PRISMA*
- Results: *Lifetimes of 11/2*$^{-}$ *states in* ^{63,65}*Co*
- Resume

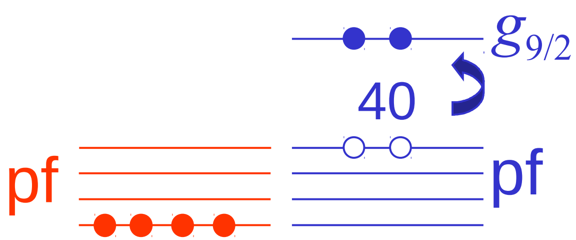
Region of deformation below N=40 ^{68}Ni

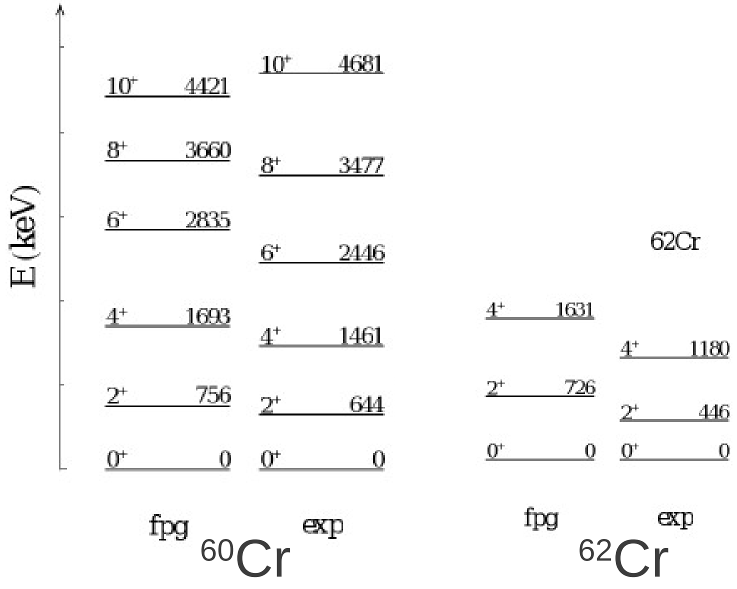
Quadrupole deformation can be generated by using a quadrupole force with the central field in the subspace spanned by a sequence of Δj = 2 orbits that come lowest by the spin-orbit splitting representing this relevant subspace a quasi-SU3. In the Fe,Cr region it happens something similar to what happens in the Island of inversion ^{32}Mg.



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 0.7 s (7/2+) n	Ni74 0.54 s 0+ n	Ni75 0.6 s (7/2+) n	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 10 ms (7/2-) n	Co72 90 ms n	Co73 (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	Fe65 0.4 s	Fe66 440 ms 0+	Fe67 470 ms (1/2-)	Fe68 0+	Fe69 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-)							

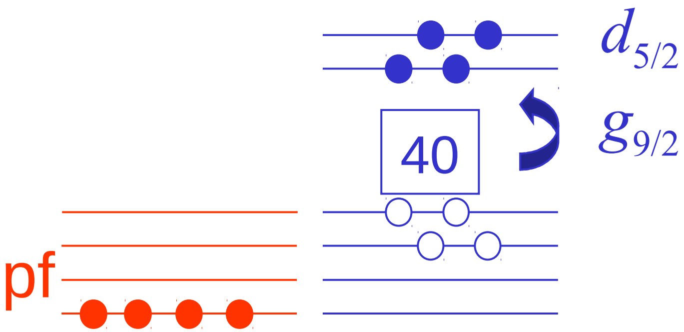
The role of the $g_{9/2}$ and $d_{5/2}$ shells

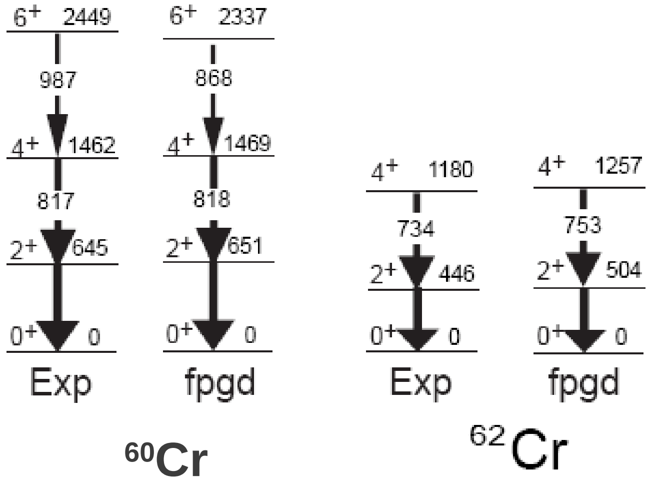




The experimental level schemes are more collective than the calculated ones.

S. Lenzi et al., *LNL* Ann. Rep. 2008

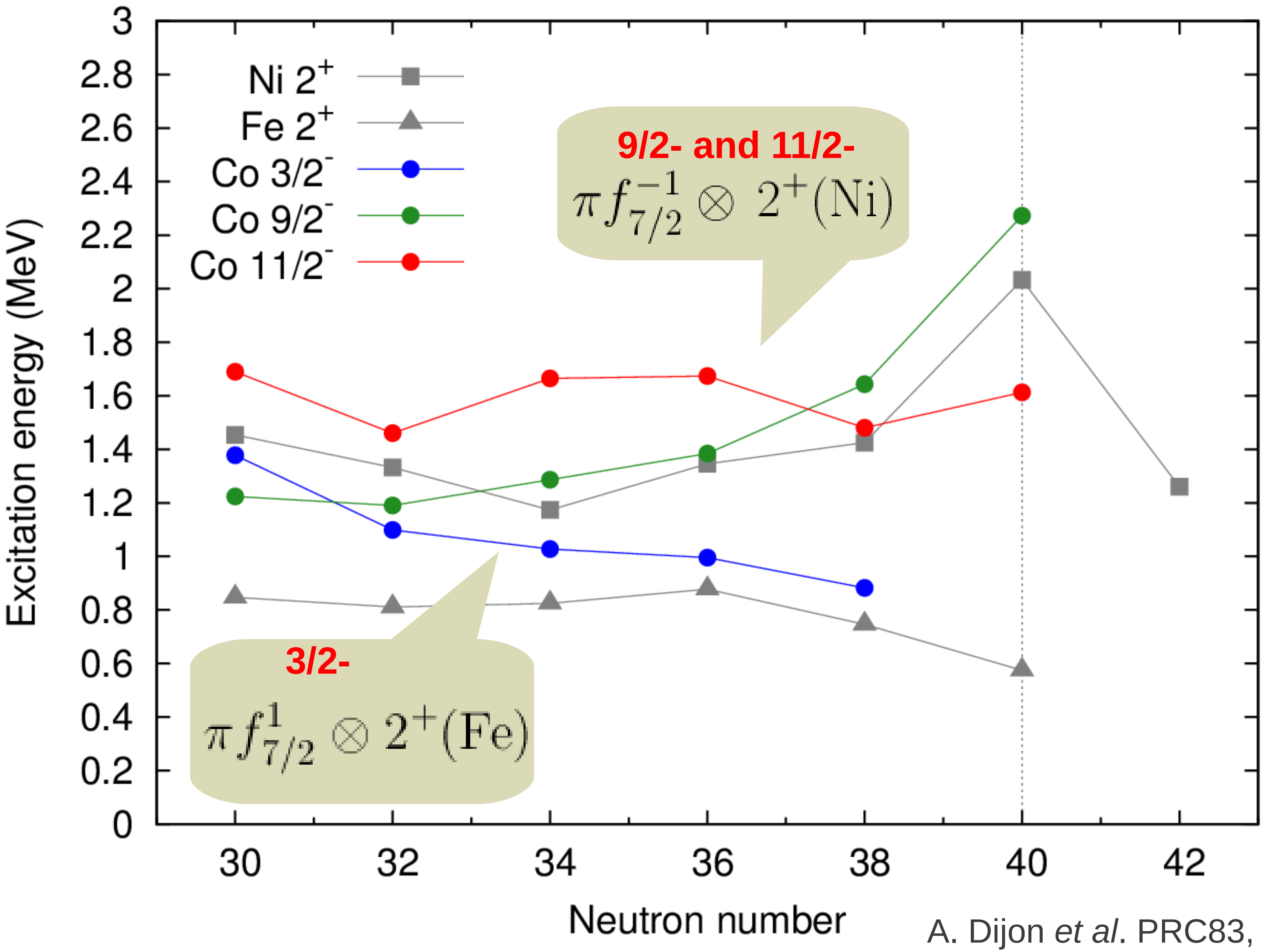




By including the neutron $d_{5/2}$ orbital in the valence space, the evolution of the deformation in the Cr isotopes is better reproduced.

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

Cobalt isotopes



9/2- and 11/2-

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

3/2-

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

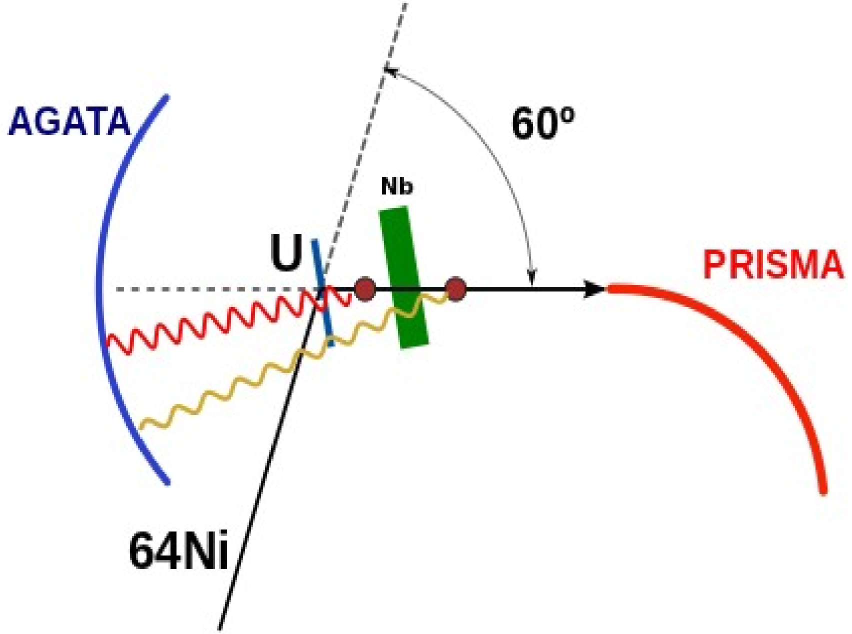
A. Dijon *et al*. PRC83, 064321 (2011)

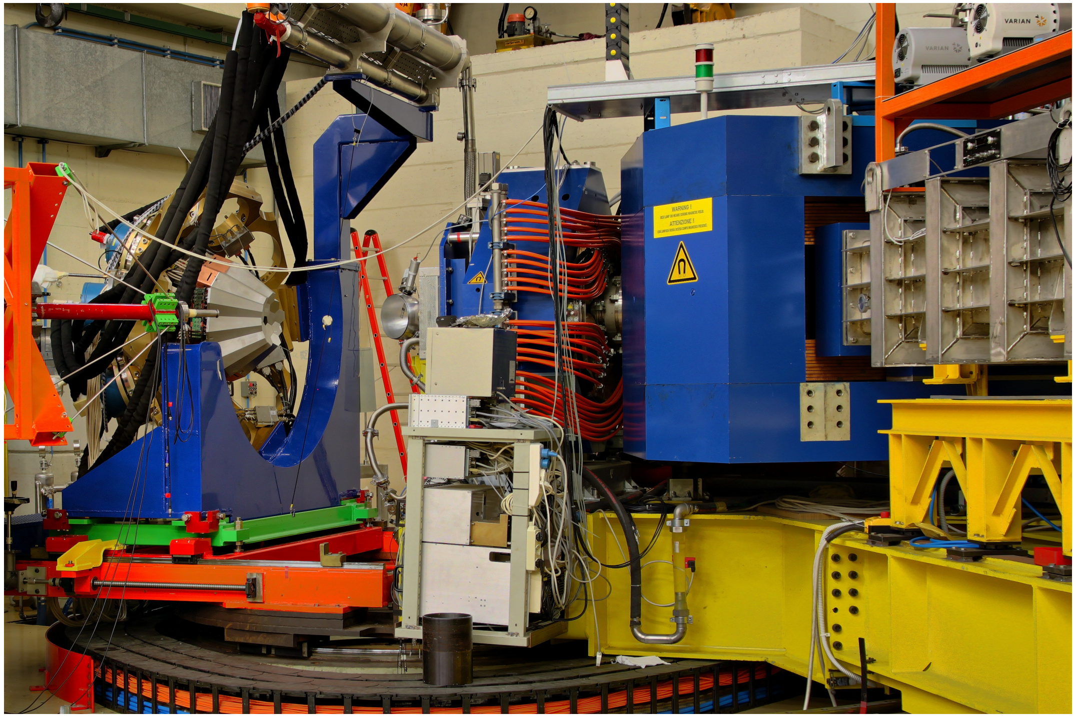
F. Recchia et al. Preprint PRC2012

Plunger experiment AGATA-PRISMA

Second Plunger exp. With AGATA (June 2010)

AGATA D. (4-cluster)
PRISMA 60º
Köln Plunger





Multi-nucleon transfer reaction

^{64}Ni + U (Grazing angle 60º)

Beam: 460 MeV (~2.5 pnA)

Target: U 1.35 mg/cm^2

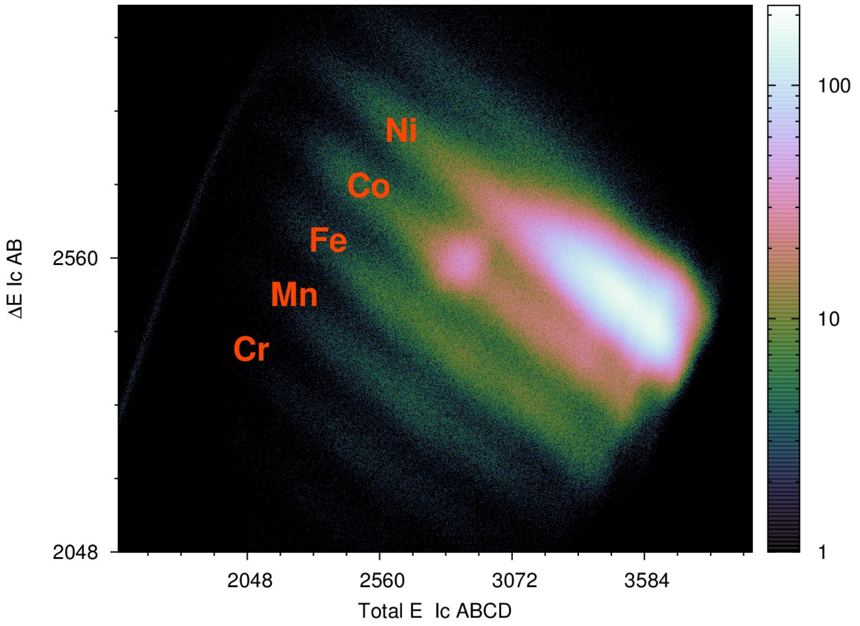
Degrader: Nb 4.13 mg/cm^2

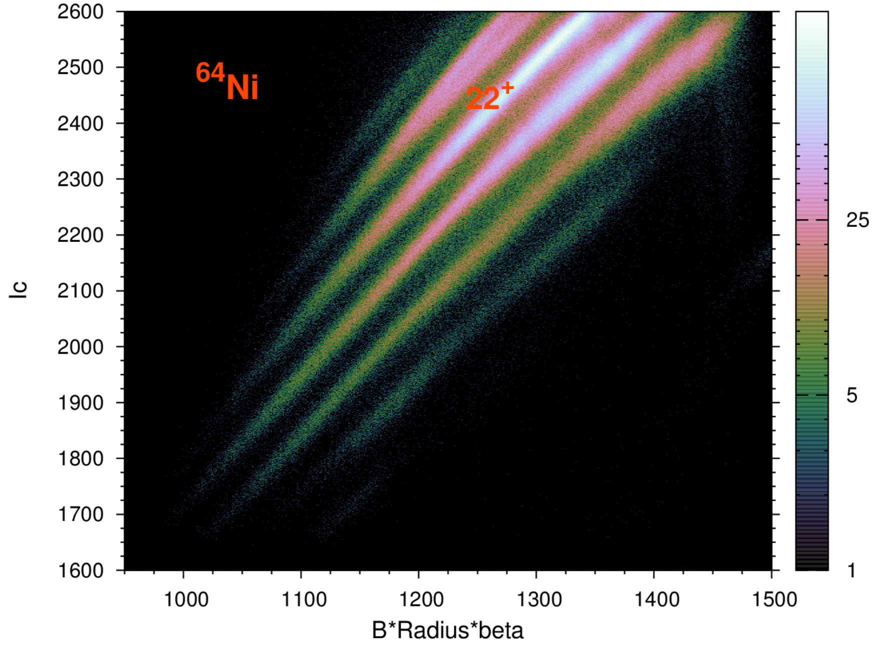
AGATA running ~80 kHz

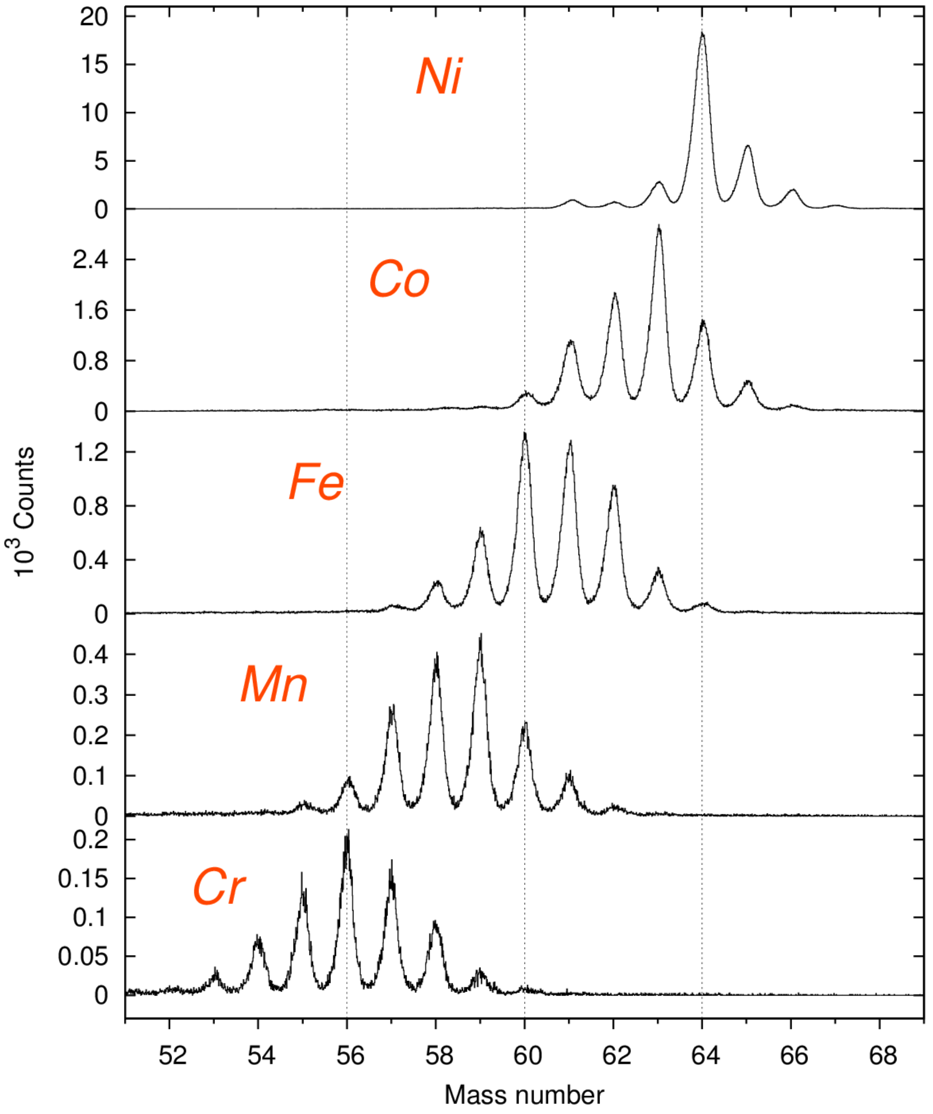
Plunger schedule

6 days experiment x3 Distances

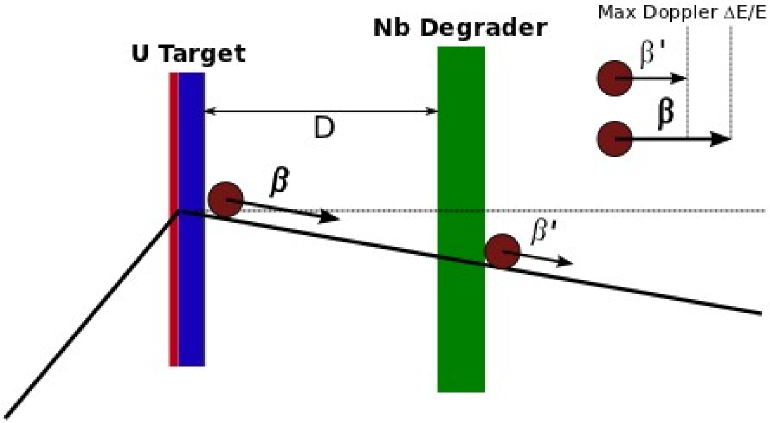
Isotope identification with PRISMA



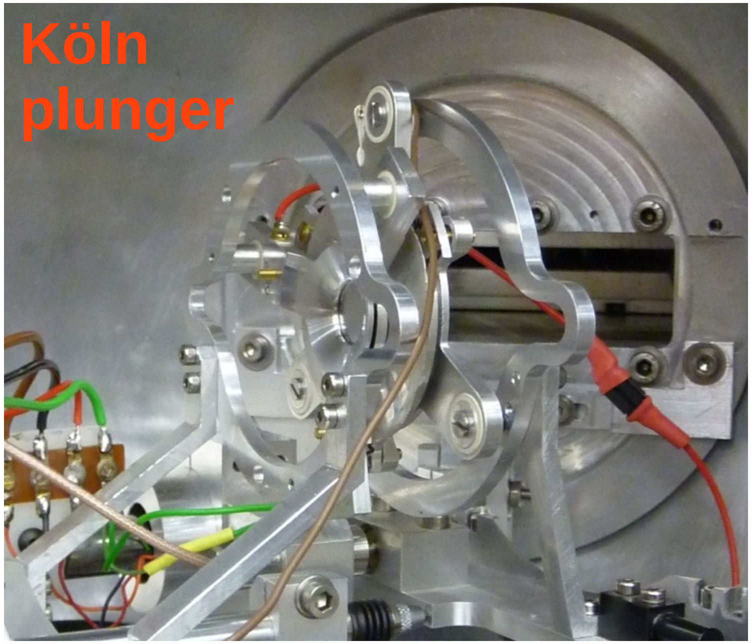


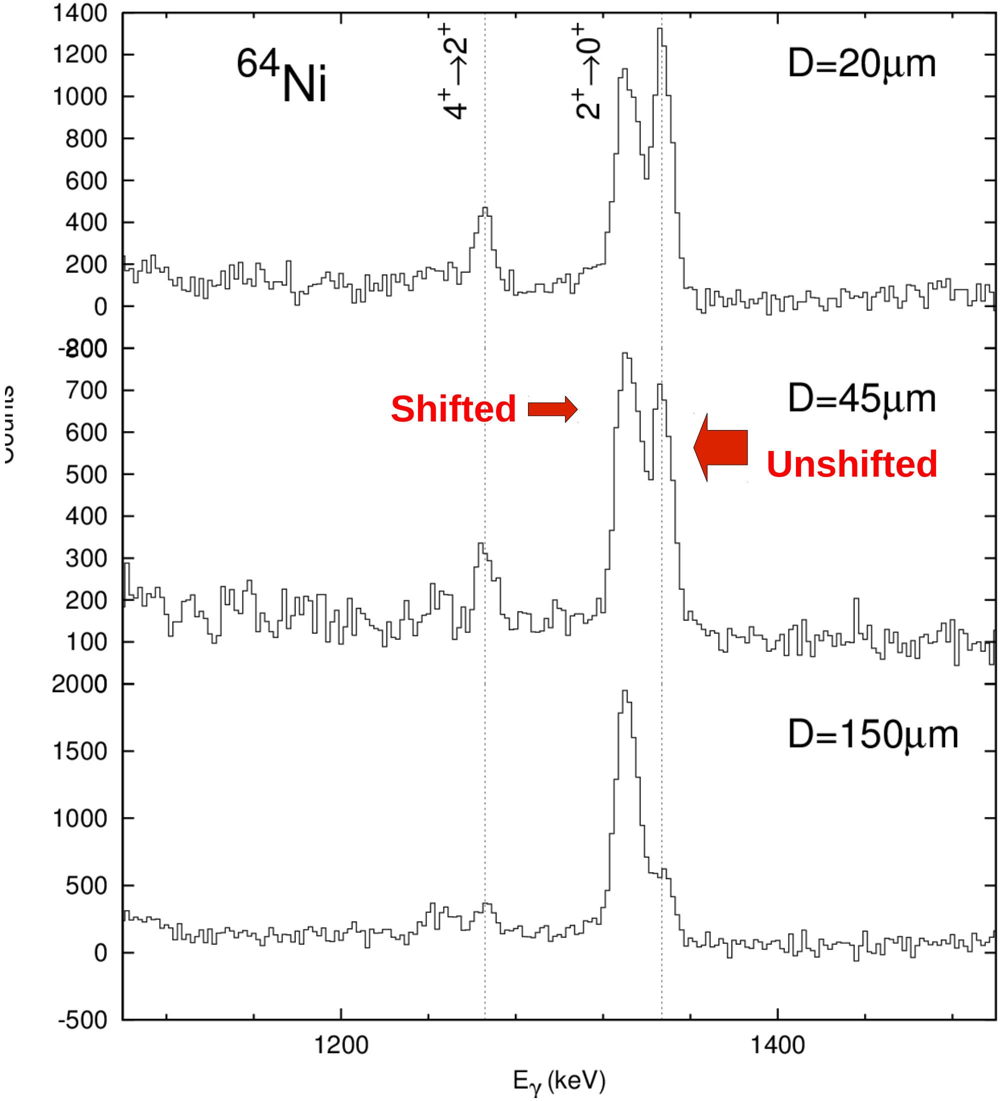


The RDDS method



$$R = \frac{I_{after}}{I_{before} + I_{after}} = exp\left(-\frac{1}{\beta\, c\, \tau}D\right)$$

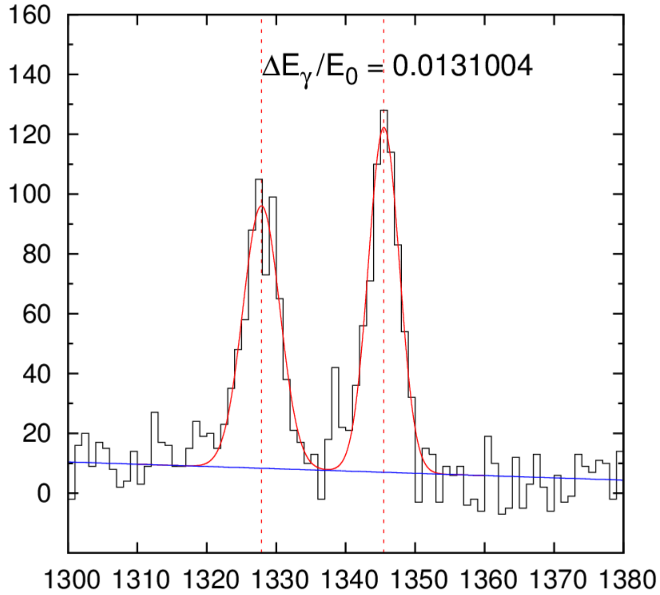


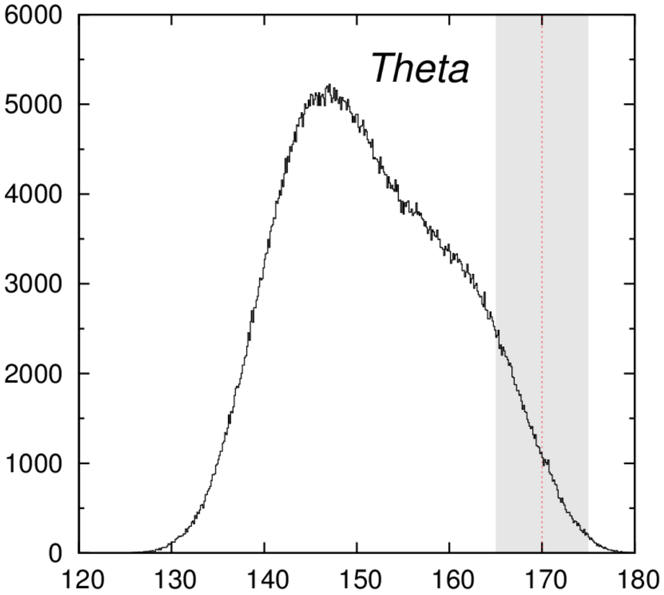


Velocity reconstruction

Beta difference driven by the degrader: obtained by measuring Doppler shift at very backward angle, together with the angular distribution.

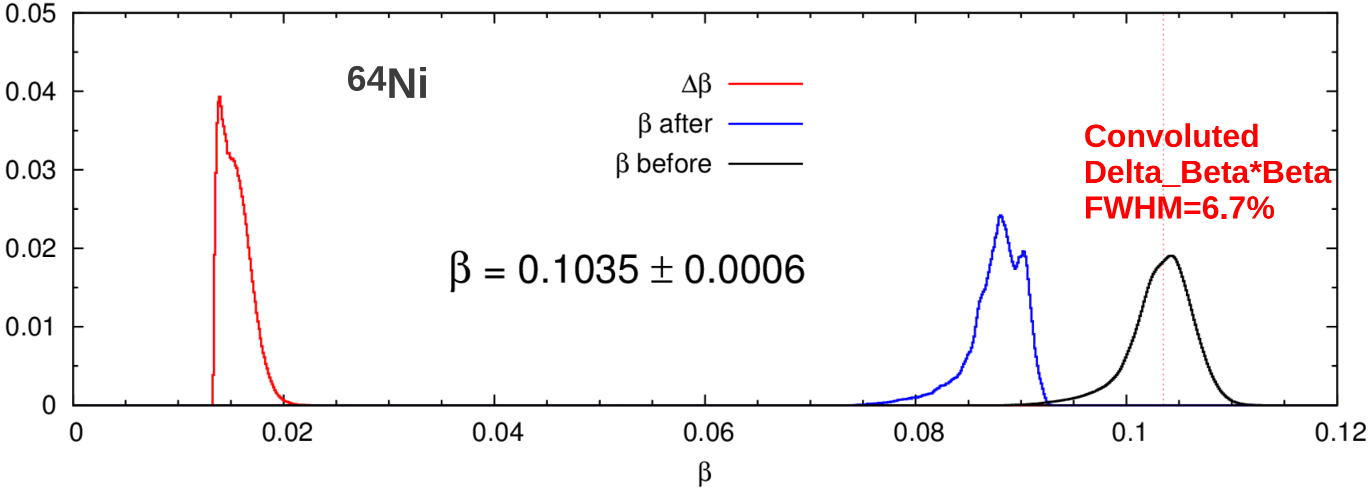
$$\frac{E_\gamma - E_\gamma^0}{E_\gamma^0} \approx \Delta\beta \cdot \mathrm{Cos}(\theta)$$





Beta before degrader: obtained with the convolution of both Δβ and β after-degrader distributions.

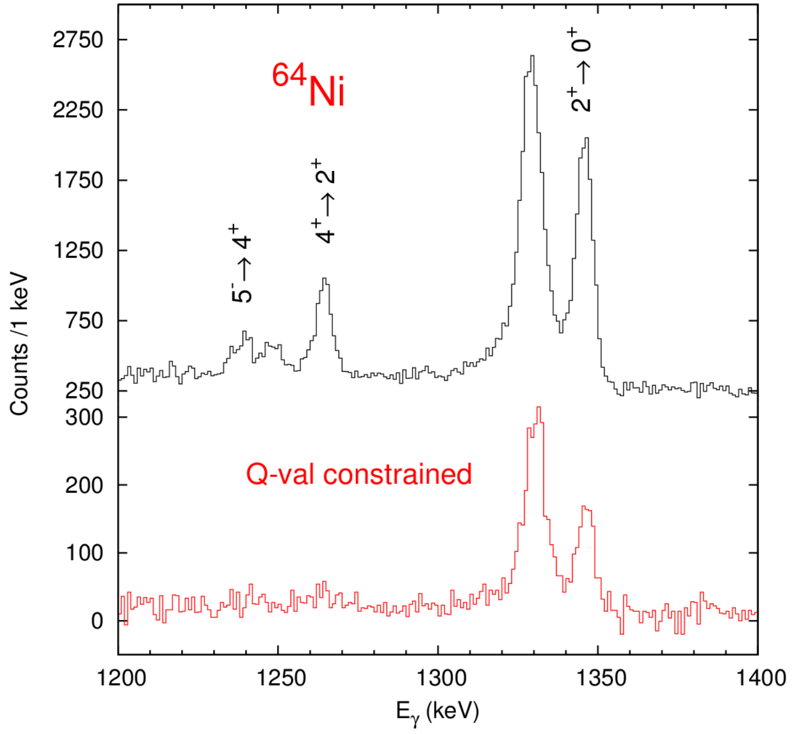
$$\beta = \beta' \otimes \Delta E/E \left(\frac{1}{\mathrm{Cos}(\theta)}\right)$$

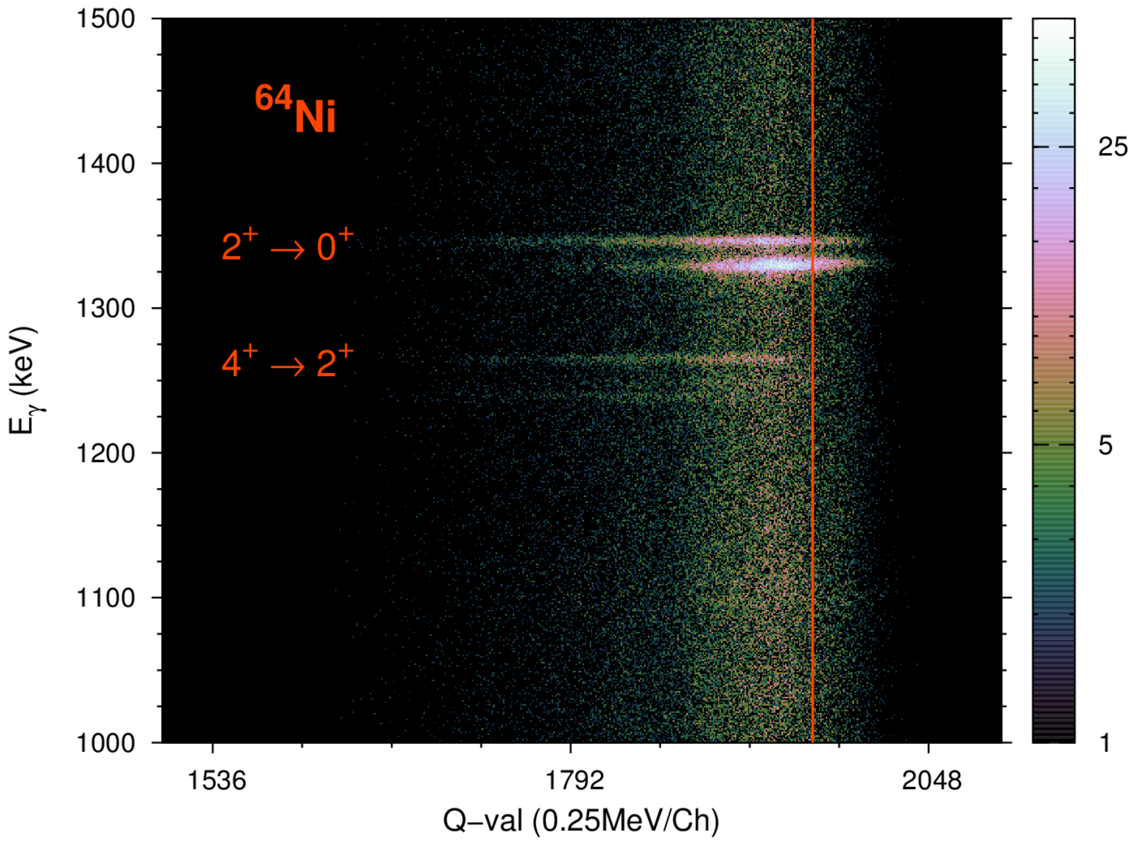


β = 0.1035 ± 0.0006

Convoluted
Delta_Beta*Beta
FWHM=6.7%

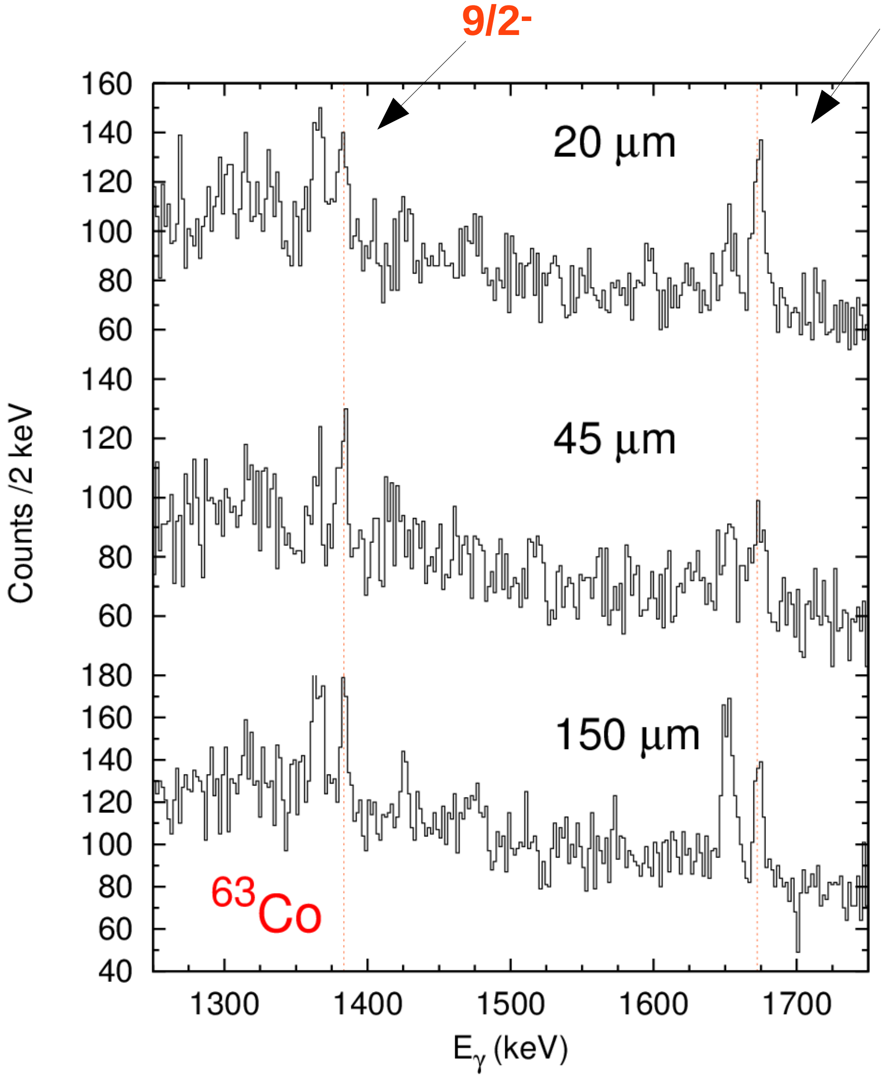
Dealing with feeding

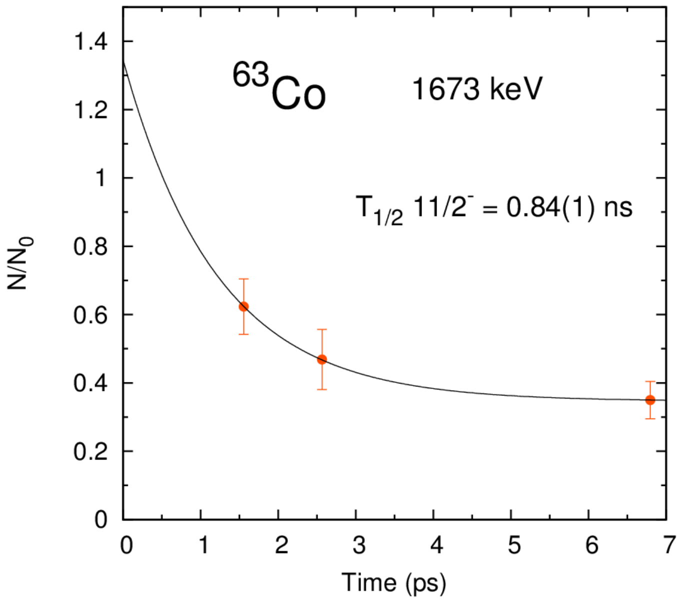


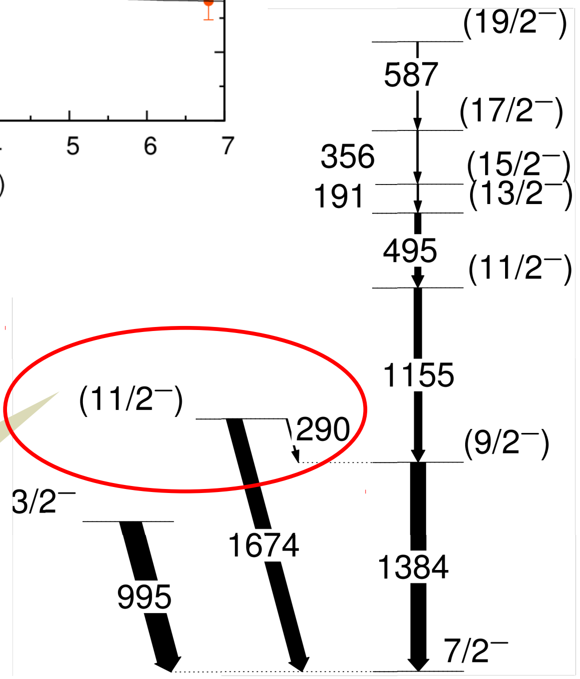


$T_{1/2}$ 2^+ = 0.99(15) ps
Previous work 1.09(4) ps

Results on ^{63}Co

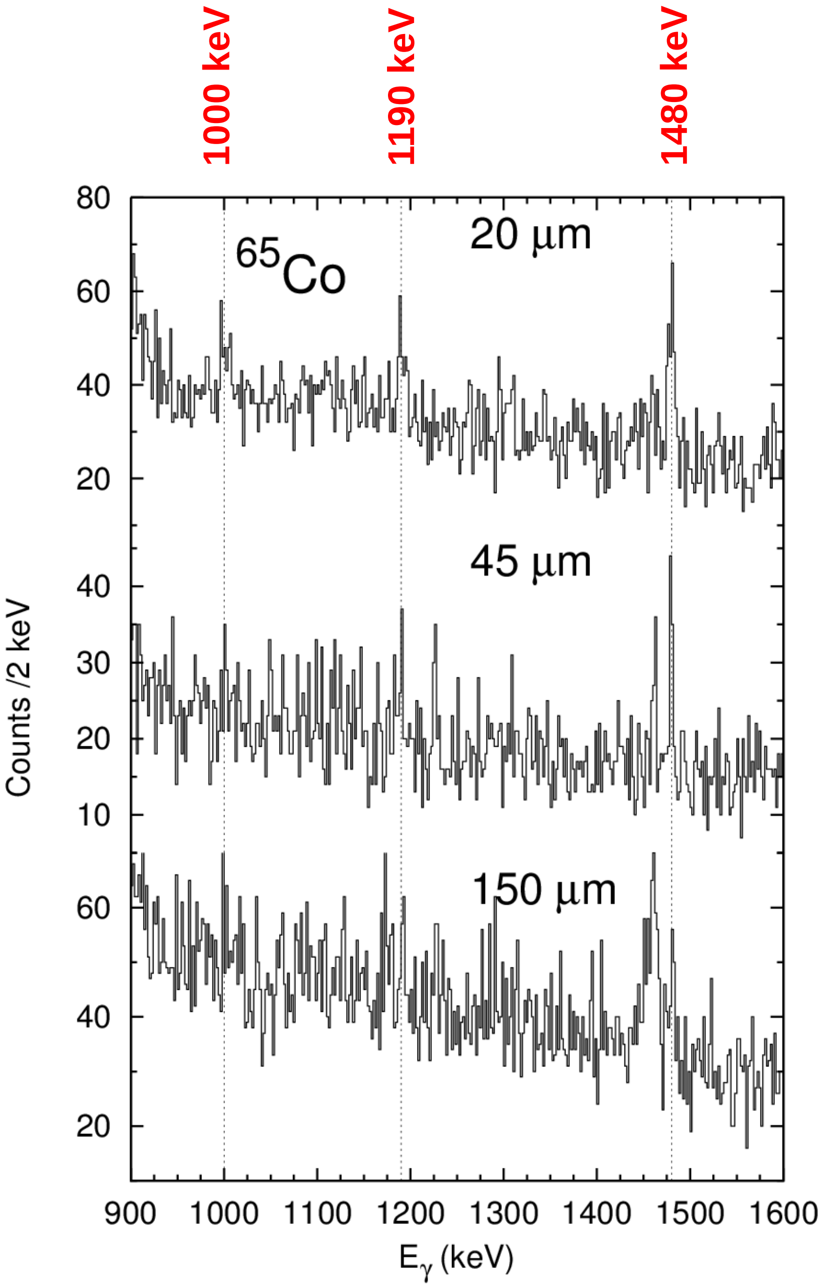


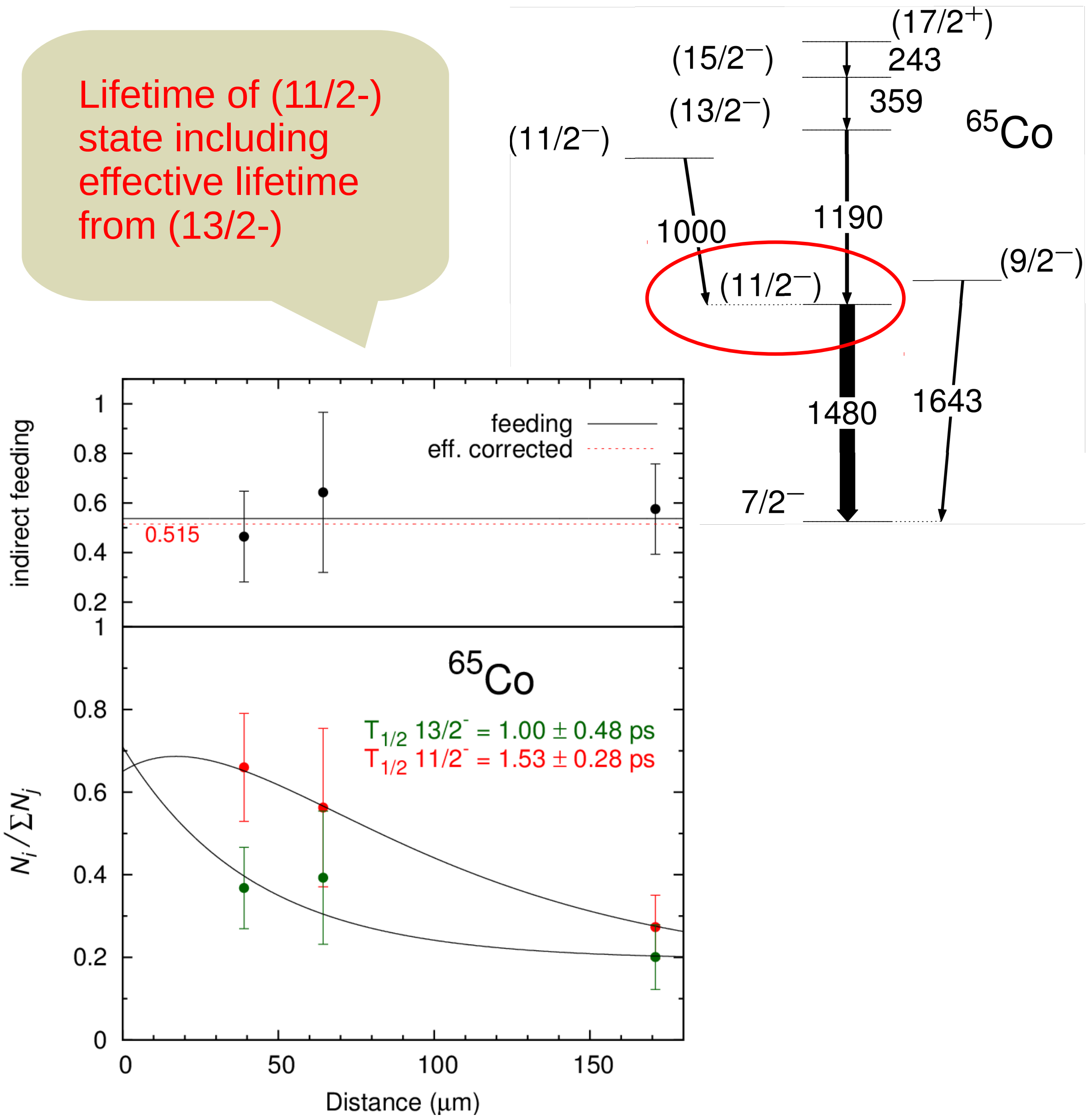




No feeding observed

Results on 65Co





Lifetime of (11/2-) state including effective lifetime from (13/2-)

^{63,65}Co 11/2- lifetimes

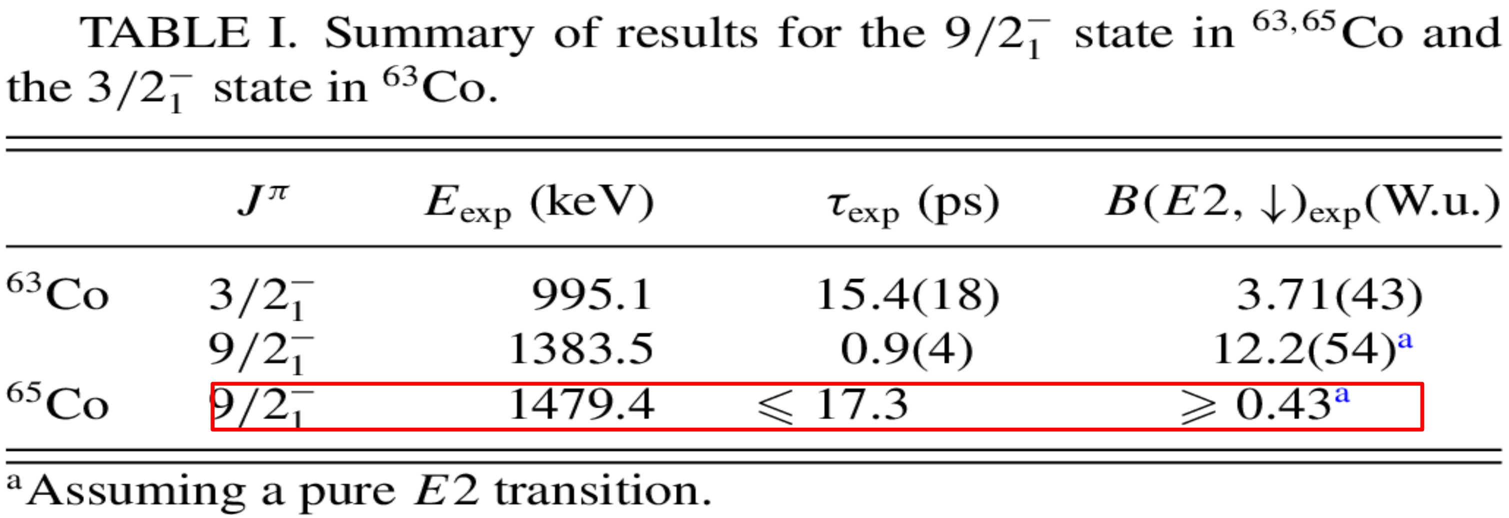


TABLE I. Summary of results for the $9/2_1^-$ state in ^{63,65}Co and the $3/2_1^-$ state in ^{63}Co.

	J^π	E_{exp} (keV)	τ_{exp} (ps)	$B(E2,\downarrow)_{\mathrm{exp}}$(W.u.)
^{63}Co	$3/2_1^-$	995.1	15.4(18)	3.71(43)
	$9/2_1^-$	1383.5	0.9(4)	12.2(54)[a]
^{65}Co	$9/2_1^-$	1479.4	$\leqslant$ 17.3	$\geqslant$ 0.43[a]

[a] Assuming a pure $E2$ transition.

A. Dijon *et al*. PRC83, 064321 (2011)

Previous work

This work:

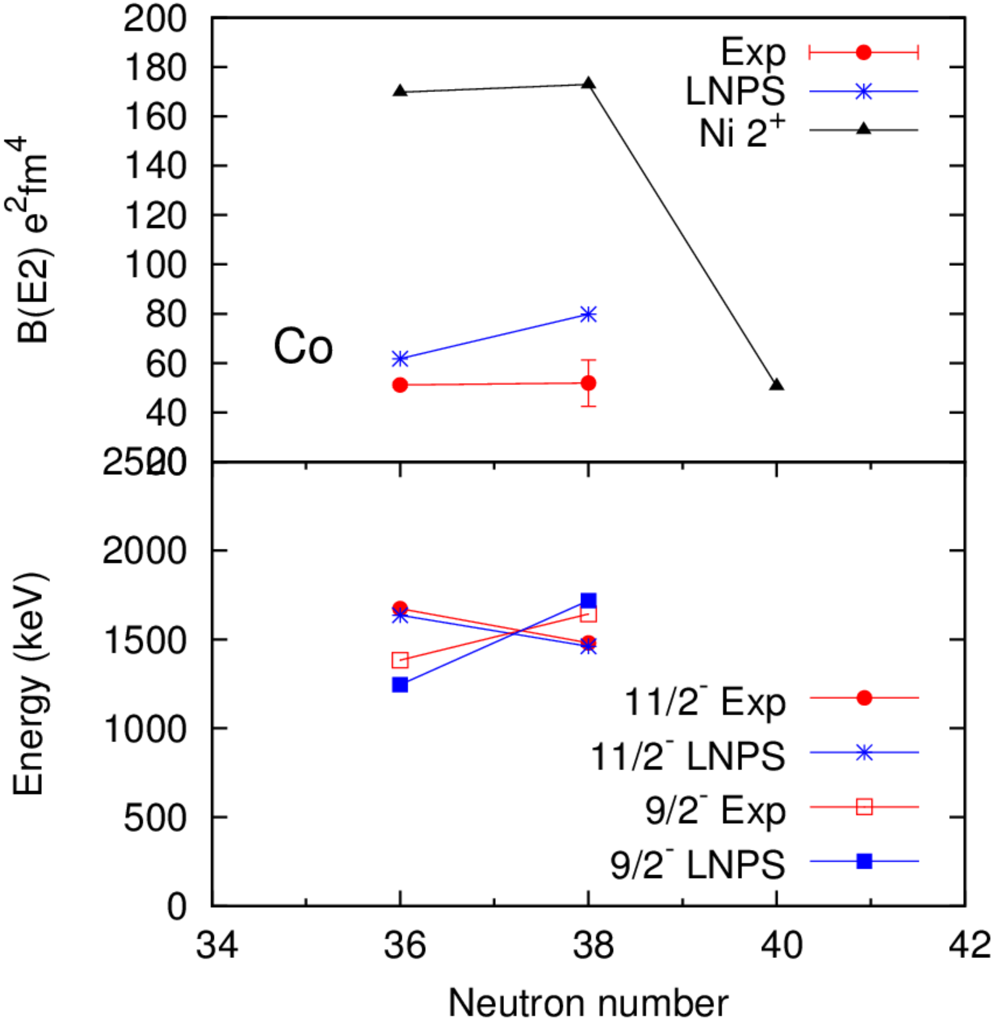
^{63}Co	**11/2-**	**1673 keV**	**$T_{1/2}$ = 0.84(1) ps**
^{65}Co	**11/2-**	**1480 keV**	**$T_{1/2}$ = 1.53(28) ps**
	$13/2^-_{\mathrm{eff}}$	**1190 keV**	**$T_{1/2}$ = 1.00(48) ps**

LNPS calculations

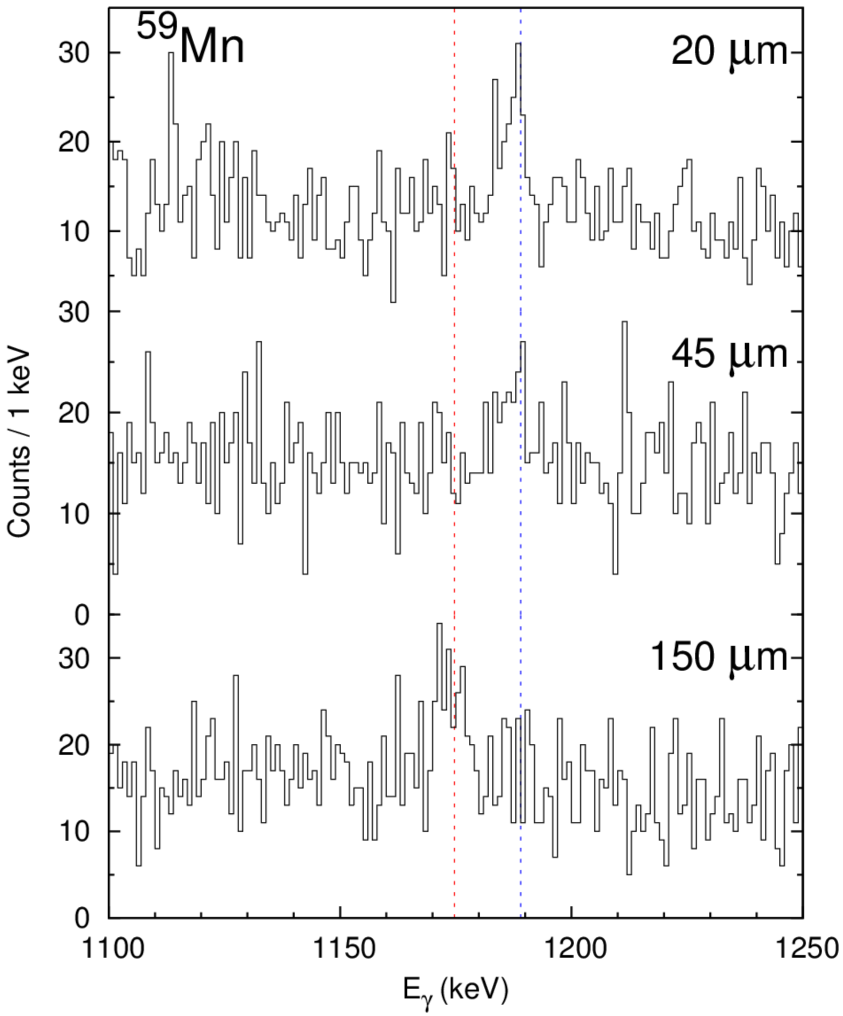
LNPS interaction: renormalized realistic interaction + monopole corrections

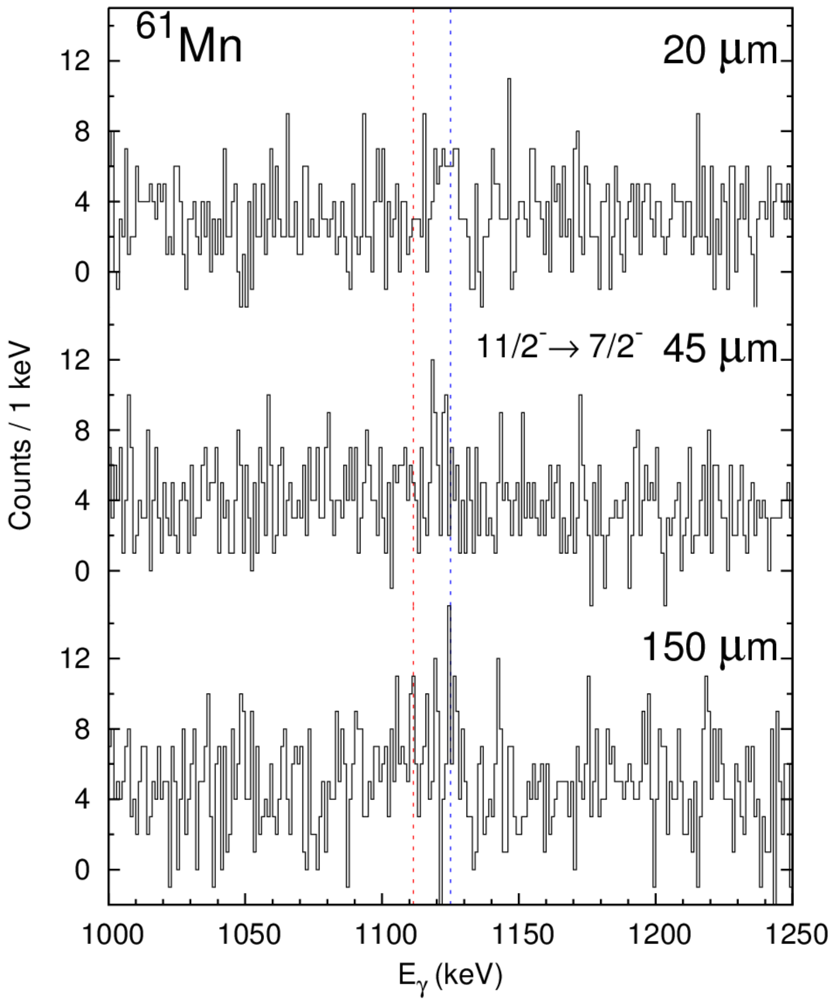
- •KB3gr for the pf-shell
- •renormalized G-matrix with monopole corrections for the remaining matrix elements involving the p3/2, p1/2, f5/2 and g9/2 neutron orbits.
- •the G-matrix based on the Kahana-Lee-Scott potential for the matrix elements involving the d5/2 orbit.
- •monopole corrections to reproduce the Z=28 and N=50 gaps in 78Ni based on data of neighboring nuclei.

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



Preliminary results on Mn isotopes





Summary

- Lifetimes for the low lying states $11/2^-$ in ^{63,65}Co have been measured for first time.
- Deduced B(E2) are compared with large-scale shell model calculations (including neutron $g_{9/2}$ and $d_{5/2}$ shells in the valence space).
- The states $11/2^-$, formerly interpreted as a $f_{7/2}$ proton hole coupled to a Ni core, entail a much more complex configuration.

Collaboration

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].

[1]INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy.
[2]Dipartimento di Fisica, Università di Padova and INFN, Sezione di Padova, Italy.
[3]Department of Physics, University of Oslo, Norway.
[4]IFIC Valencia, Spain.
[5]IKP, Universitätt zu Köln, Köln, Germany.
[6]Department of Physics, Istanbul University, Istanbul, Turkey.
[7]Department of Physics, University of Surrey, Guildford, U.K.
[8]Dipartimento di Fisica, Università di Firenze and INFN, Sezione di Firenze, Firenze, Italy.
[9]University of the West of Scotland, Paisley, Scotland.
[10]Technische Universität Darmstadt, Darmstadt, Germany.
[11]RIKEN Nishina Center for Accelerator Based Science, Wako-shi, Japan.
[12]Ruder Boskovic Institute, Zagreb, Croatia.