Coulomb excitation of the neutron-rich ^{67,69,71,73}Cu with Miniball and REX-ISOLDE

Experiment IS435

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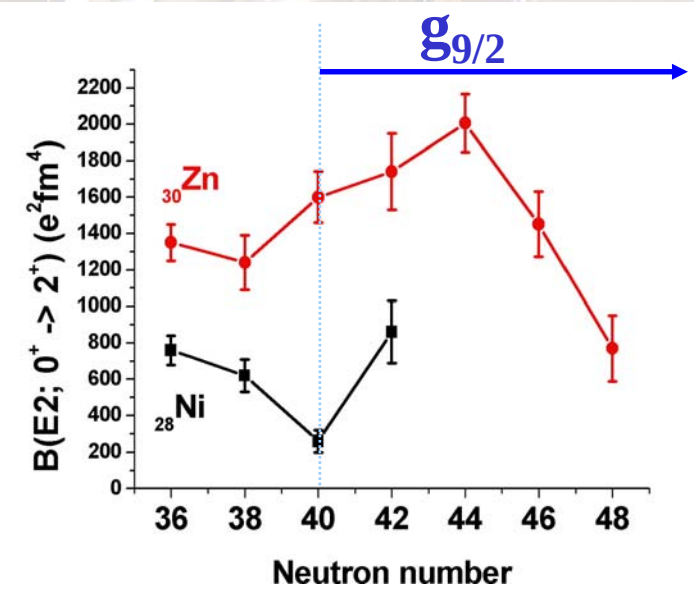
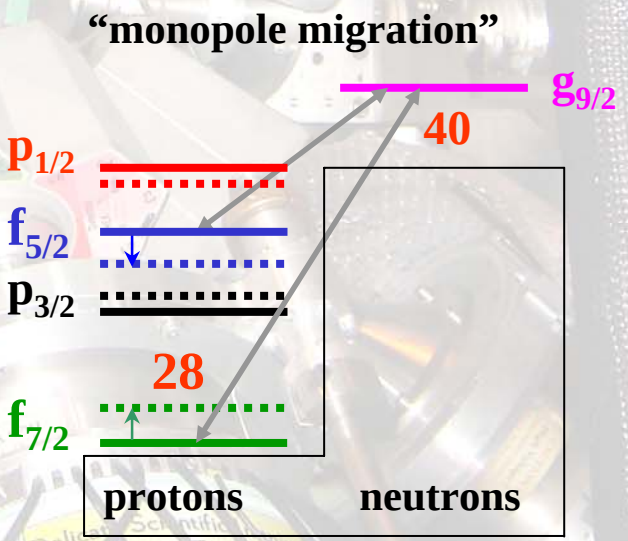
Beyond ^{68}Ni by Coulomb excitation with RIBs

	Zn66	Zn67	Zn68	Zn69	Zn70	Zn71	Zn72	Zn73	Zn74	Zn75	Zn76	Zn77	Zn78	Zn79	Zn80	Zn81
	0+ 27.9	5/2- 4.1	0+ 18.8	56.4 m 1/2-	5E+14 y 0+ 0.6	2.45 m 1/2-	46.5 h	23.5 s (1/2)-	95.6 s	10.2 s (7/2+)	5.7 s	2.08 s (7/2+)	1.47 s	995 ms (9/2+)	0.545 s	0.29 s
	Cu65 3/2- 30.83	Cu66 5.088 m 1+	Cu67 61.83 h 3/2-	Cu68 31.1 s	Cu69 2.85 m 3/2-	Cu70 4.5 s	Cu71 19.5 s (3/2-)	Cu72 6.6 s (1+)	Cu73 3.9 s	Cu74 1.594 s (1+,3+)	Cu75 1.224 s	Cu76 0.641 s	Cu77 469 ms	Cu78 342 ms	Cu79 188 ms	Cu80
28	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	Ni71 1.86 s	Ni72 2.1 s 0+	Ni73 0.90 s	Ni74 1.1 s 0+	Ni75	Ni76 0+	Ni77	Ni78 0+	
	Co63 27.4 s (7/2)-	Co64 0.30 s 1+	Co65 1.20 s (7/2)-	Co66 0.23 s (3+)	Co67 0.42 s (7/2-)	Co68 0.18 s	Co69 0.27 s	Co70	Co71	Co72						

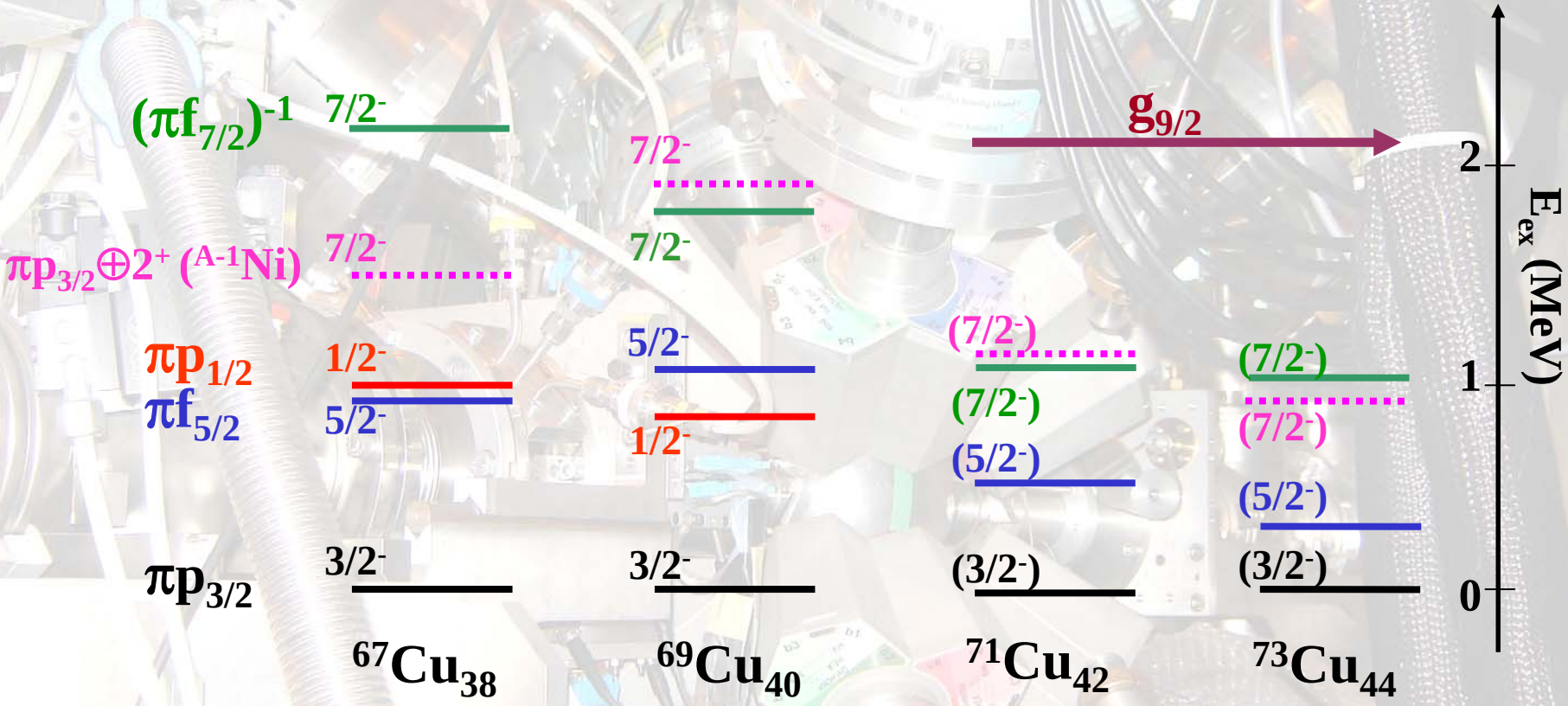
36 38 40 42 44 46 48 50

★ measured by Coulex with RIBs





^{67,69,71,73}Cu and the monopole migration

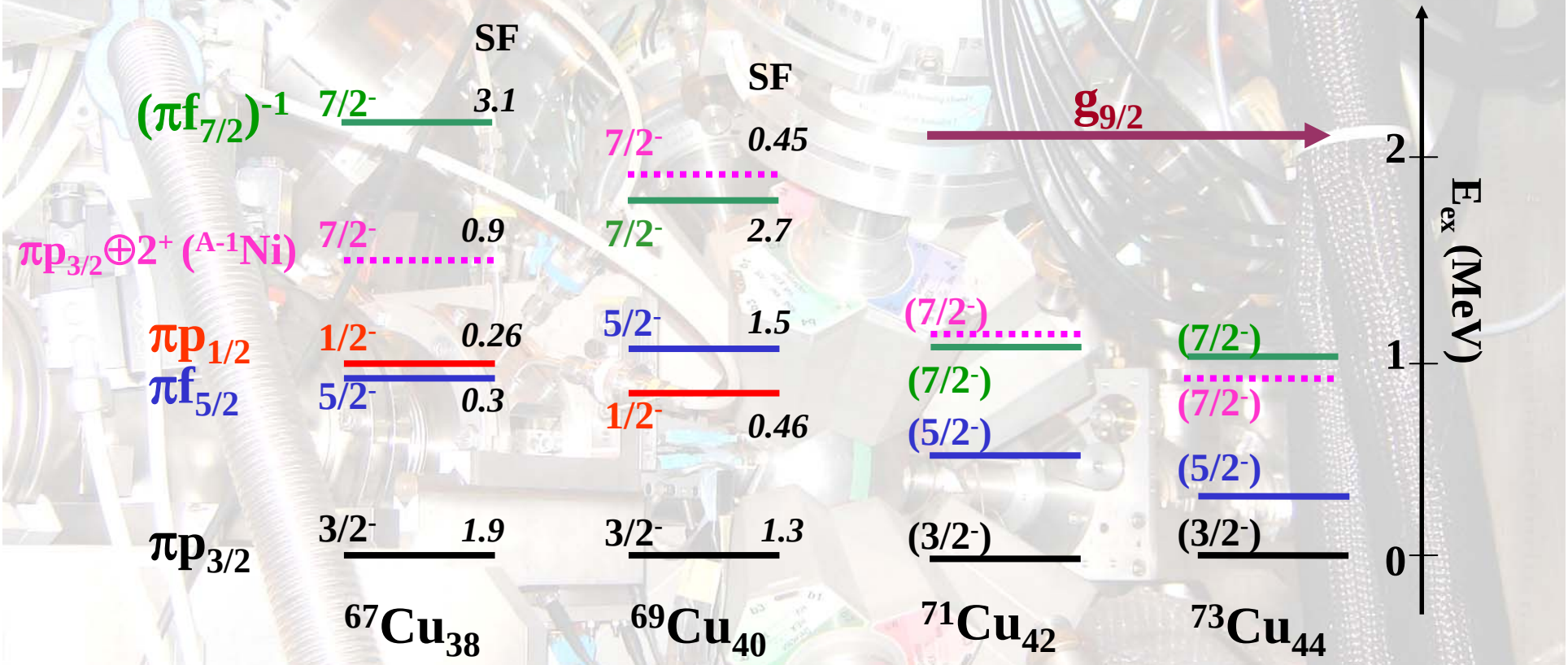


^{67,69}Cu: B. Zeidman et al., PRC 18, 2122(1978).

^{71}Cu: R. Grzywacz et al., PRL 81, 766 (1998).

^{69,71,73}Cu: S. Franchoo et al., PRL 81, 3100(1998).

^{67,69,71,73}Cu and the monopole migration



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Radioactive beams of ^{67,69,71,73}Cu

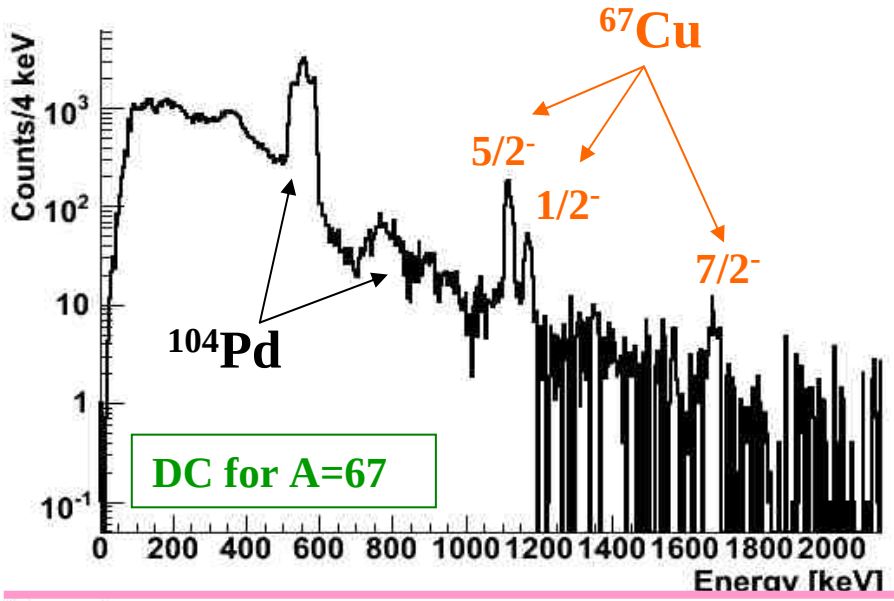
- UC_x target – Ta line
- ionized by RILIS
- REX: ~2.95 MeV/u
- beams contaminated with the Ga isobar
- laser ON/OFF runs → ^{67}Cu/total~ 98 %

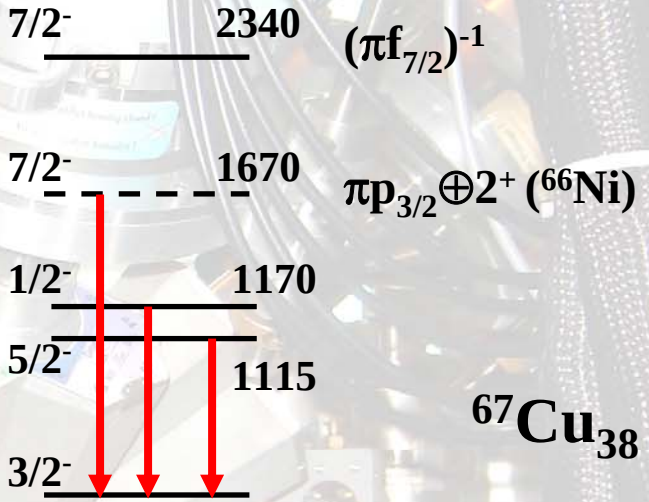
  ^{69}Cu/total~ 94 %

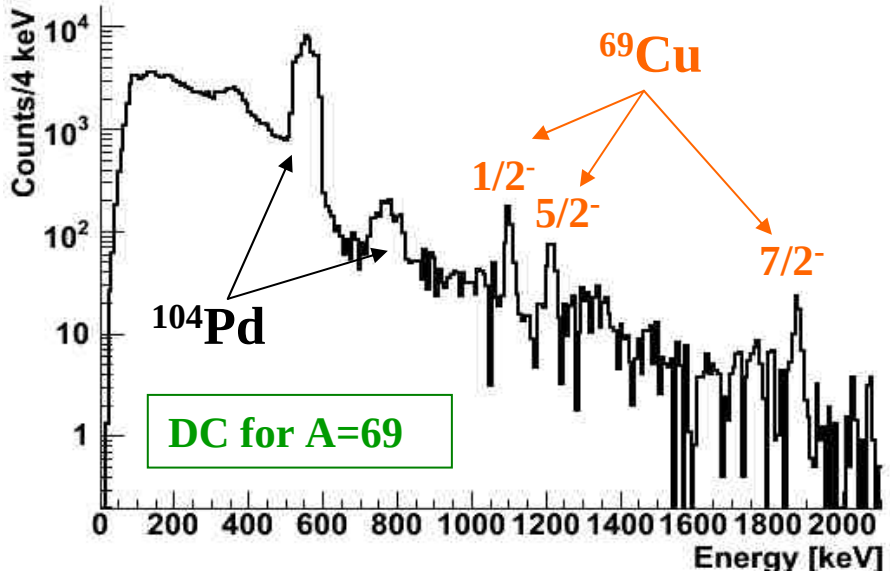
  ^{71}Cu/total~ 76 %

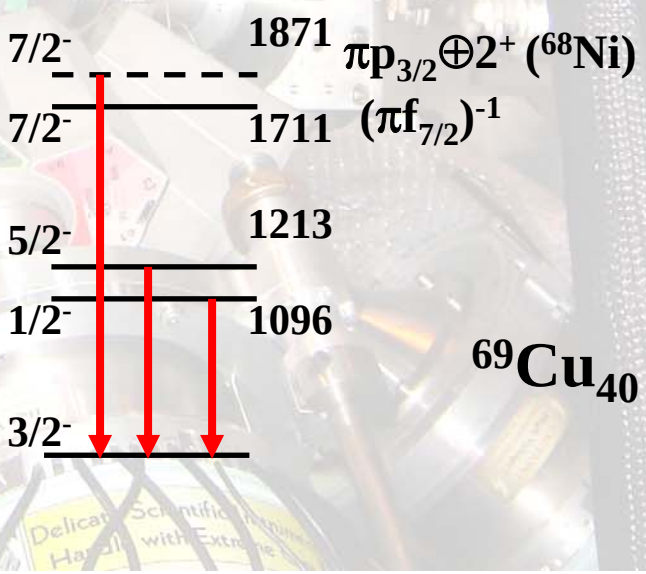
  ^{73}Cu/total~ 19 %

Experimental results (1)

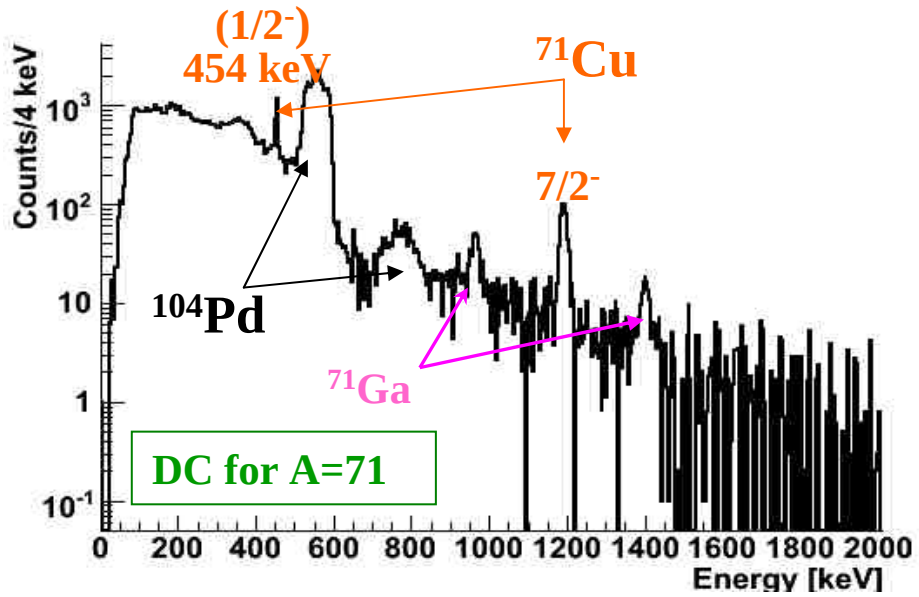


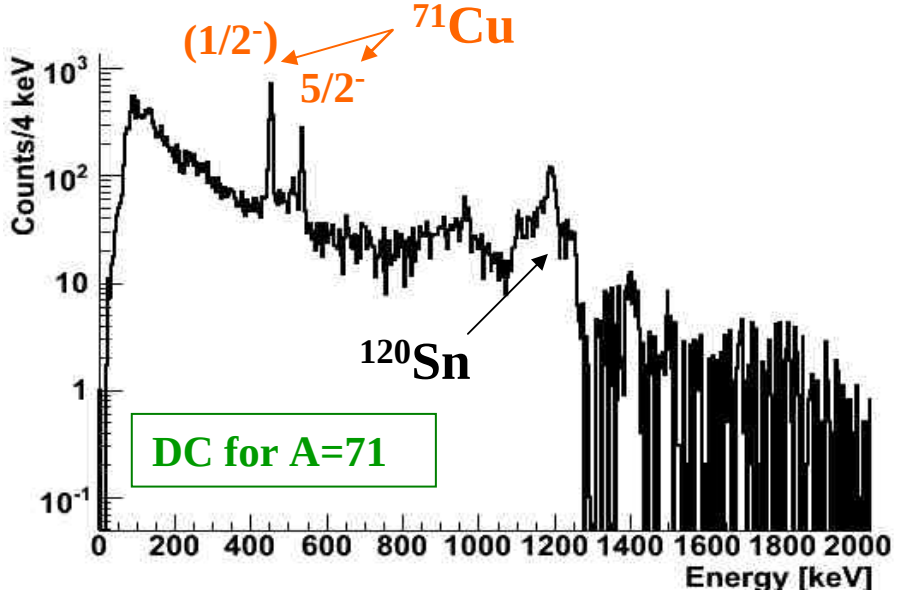


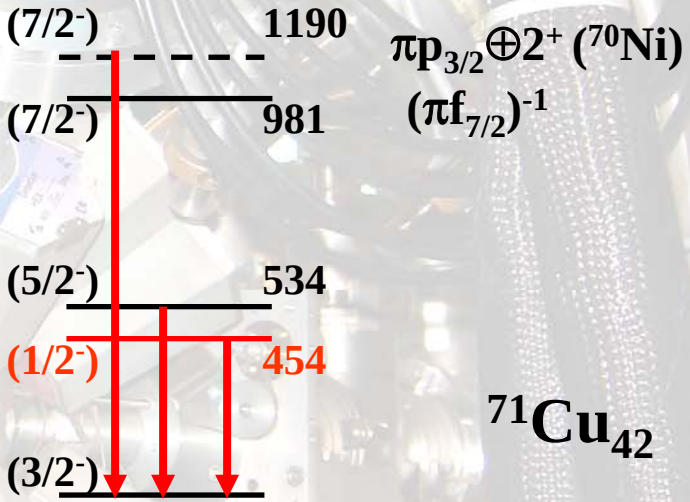




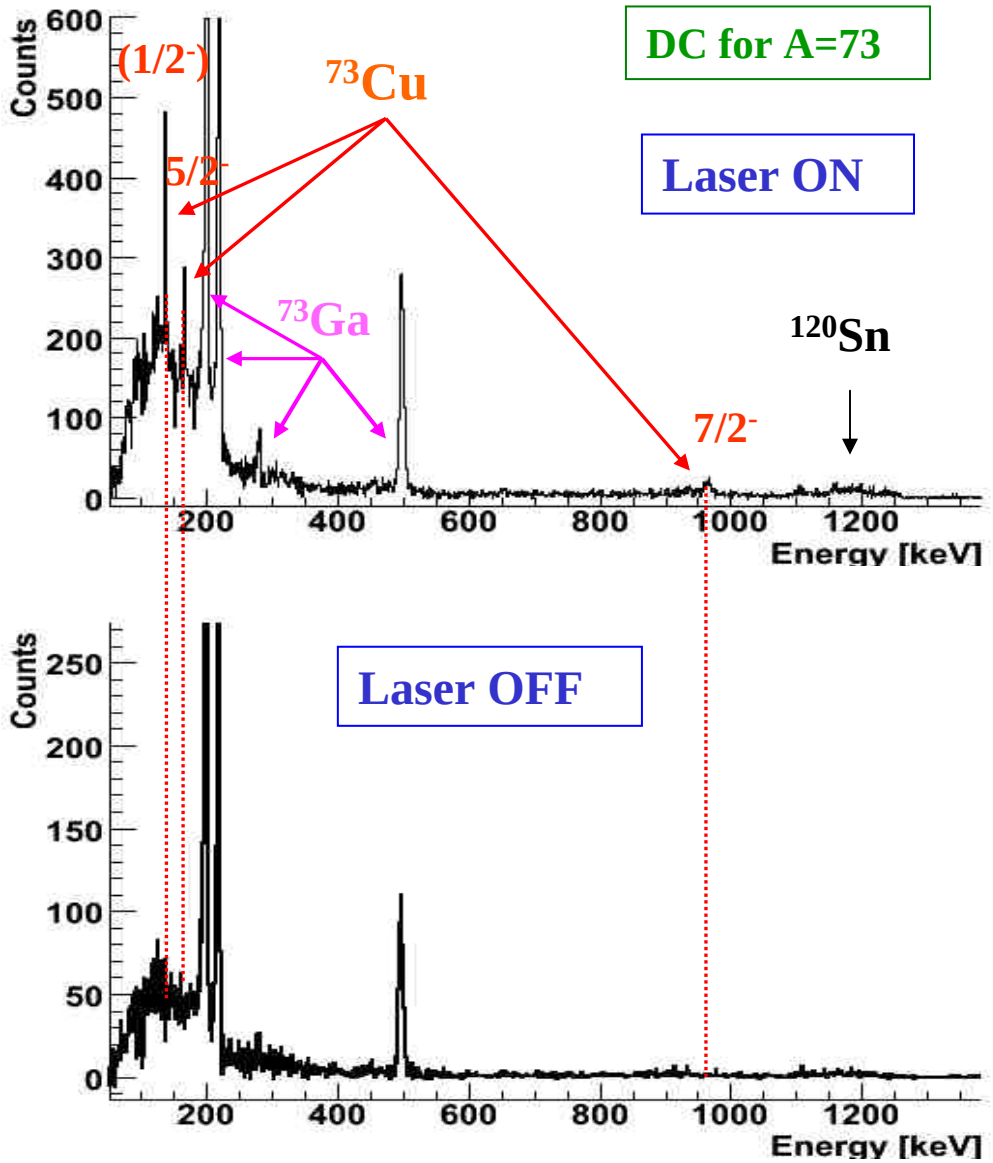
Experimental results (2)

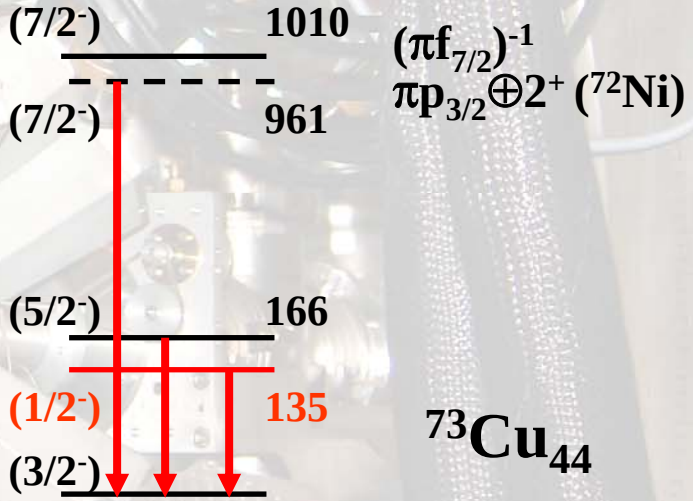




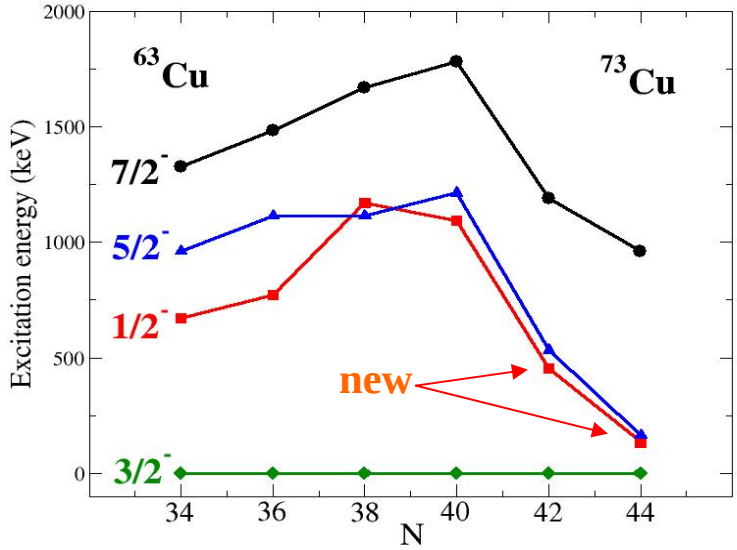


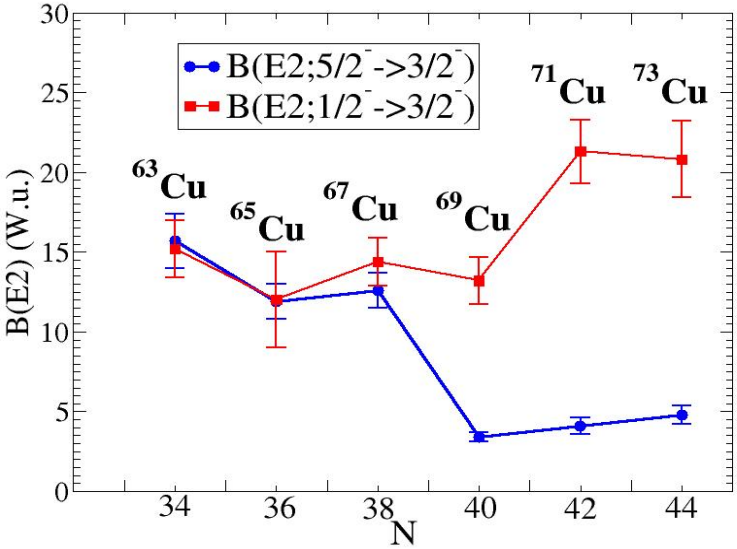
Experimental results (3)

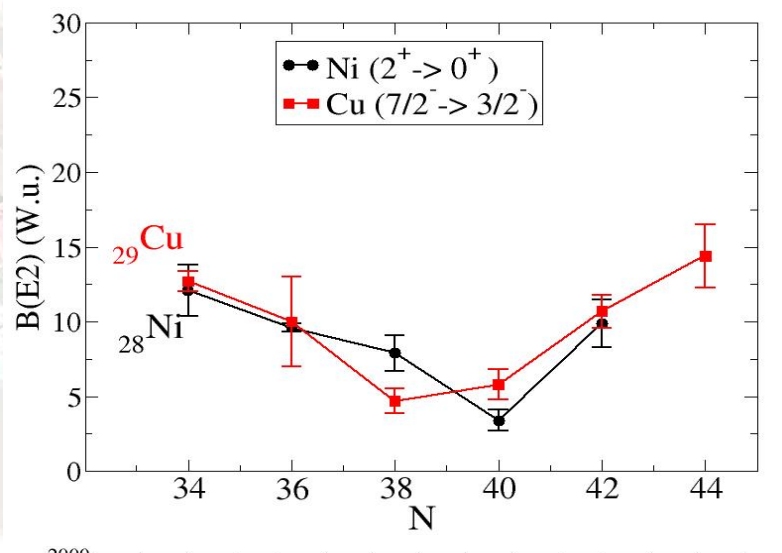


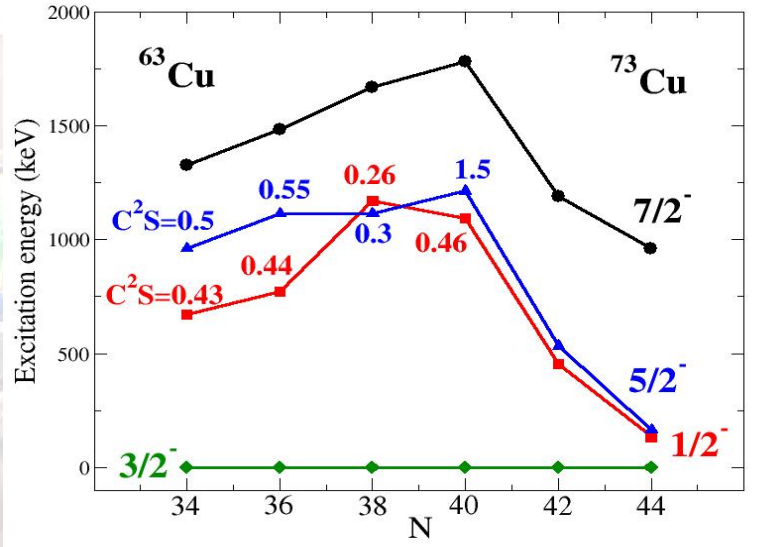


Experimental results (preliminary)



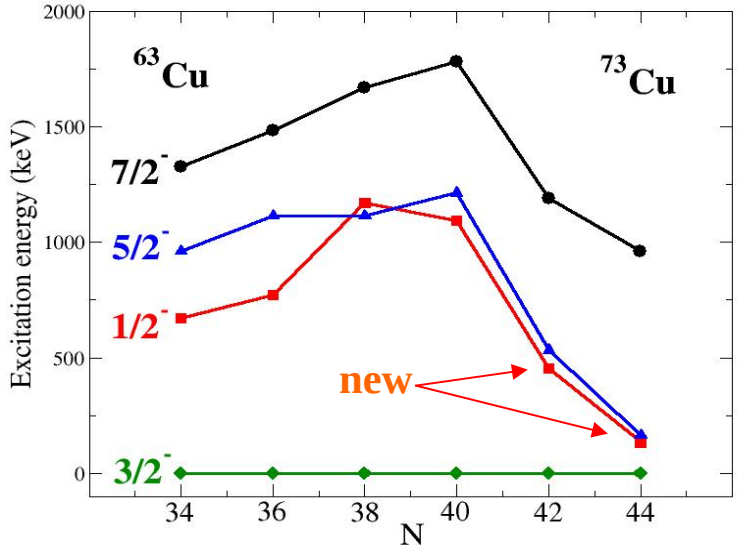


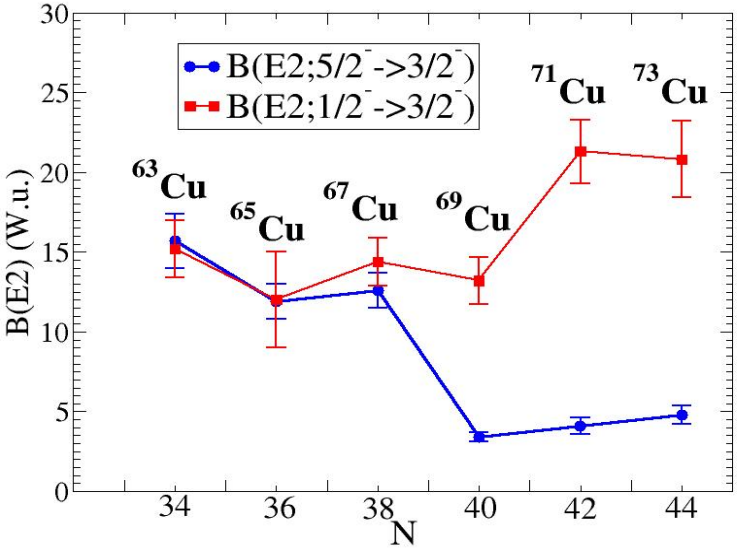


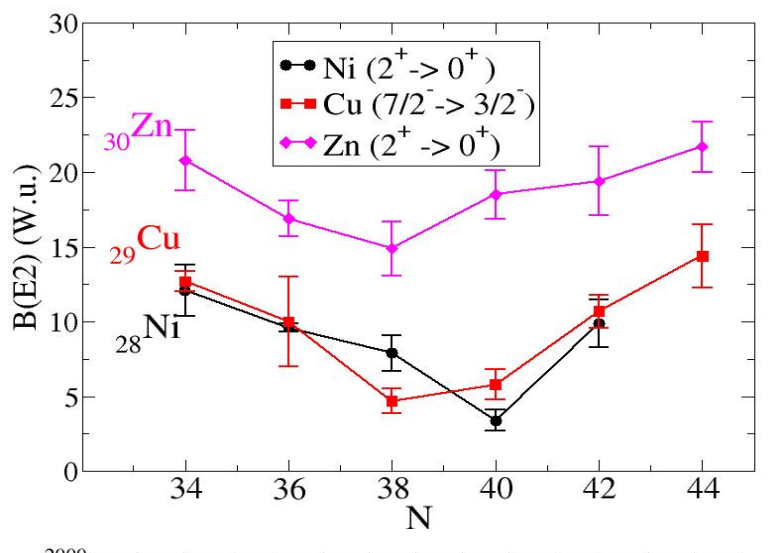


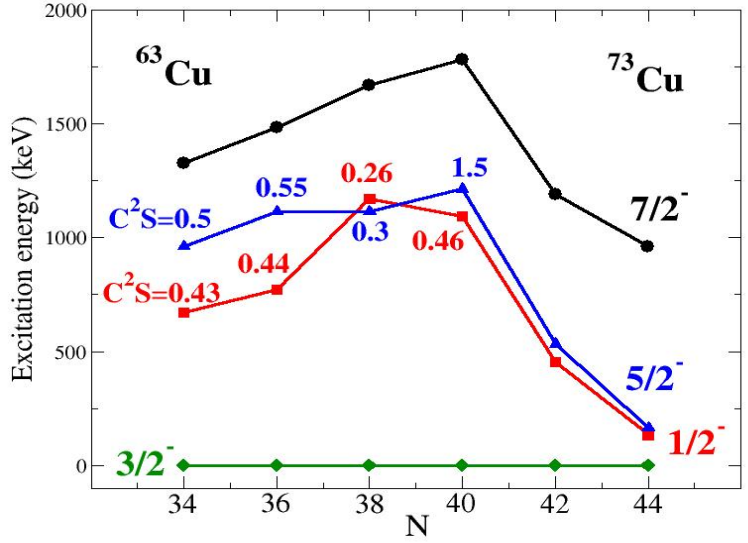
spectroscopic factors from B. Zeidman et al., PRC 18, 2122(1978).

Experimental results (preliminary)









spectroscopic factors from B. Zeidman et al., PRC 18, 2122(1978).

Conclusion and outlook

✓ **Summer 2006 ➔ Coulex of ^{67,69,71,73}Cu;**

✓ **three B(E2) values measured in each isotope;**

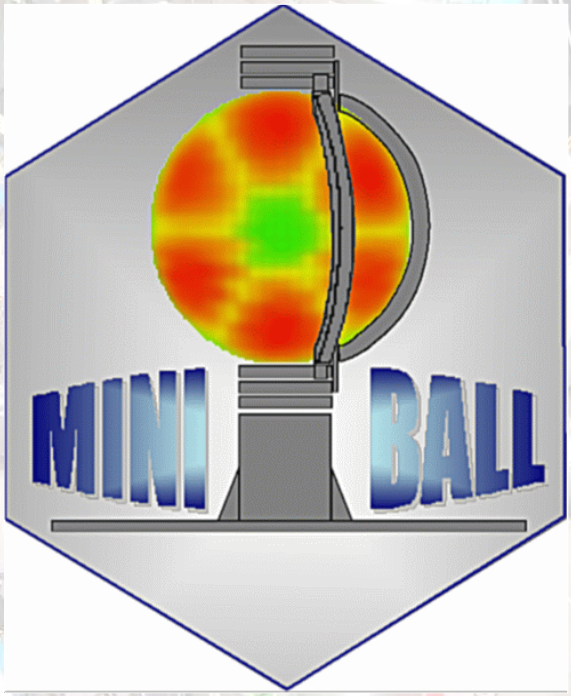
✓ **$\frac{1}{2}^-$ identified in ^{71,73}Cu.**

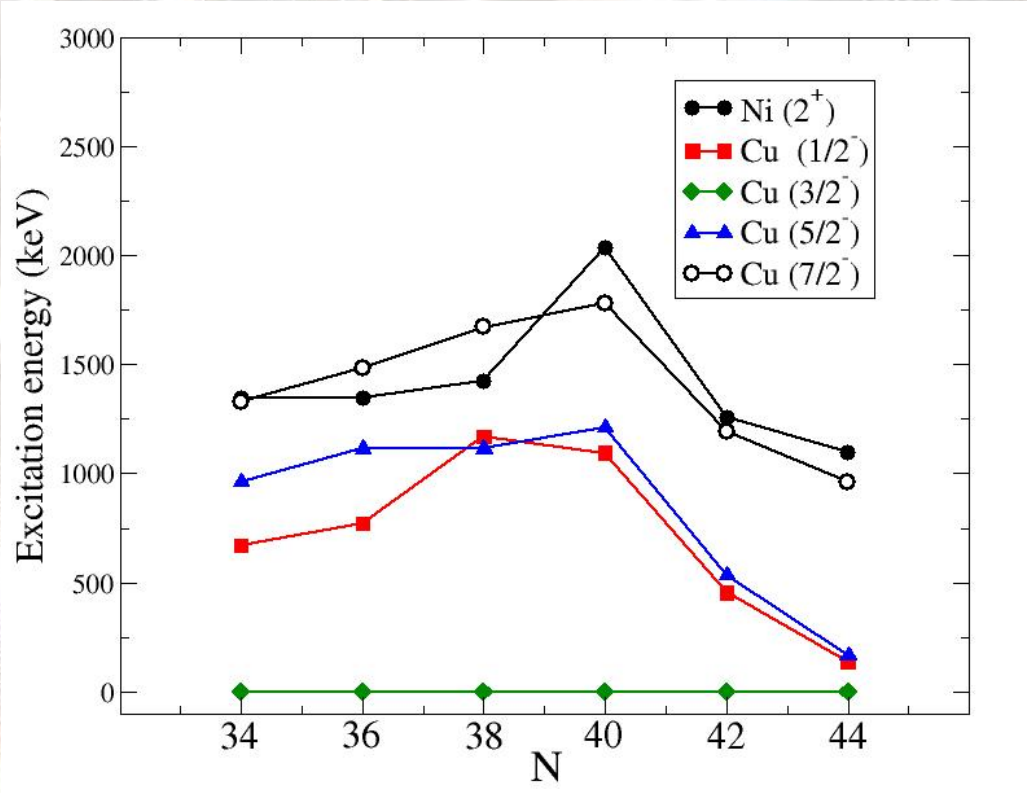
➢ **strong effects of the N=40 sub-shell closure on the structure of the odd-mass Cu isotopes;**

➢ **highly collective $1/2^-$ state and single-particle-like $5/2^-$ level in ^{69,71,73}Cu;**

➢ **interpreting the implications of the present results requires some theoretical input.**

➢ **Summer 2007 ➔ Coulex of ^{75}Cu**


MINI BALL

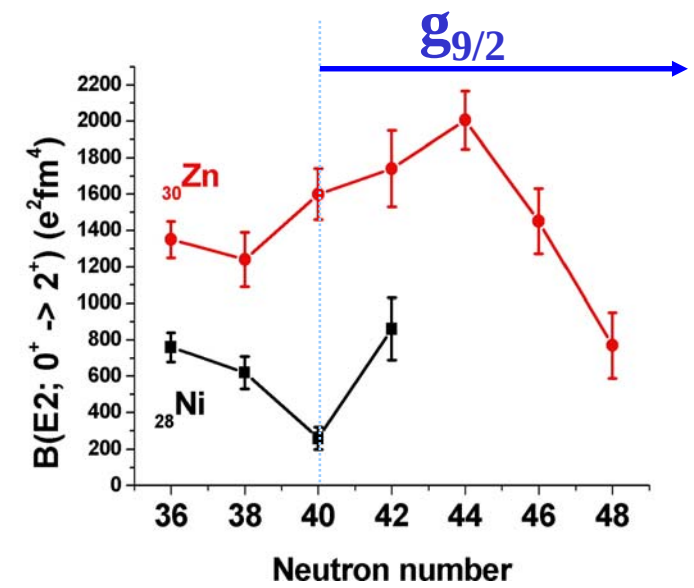

Excitation energy (keV)
3000
2500
2000
1500
1000
500
0
34
36
38
40
42
44
N
Ni (2+)
Cu (1/2-)
Cu (3/2-)
Cu (5/2-)
Cu (7/2-)

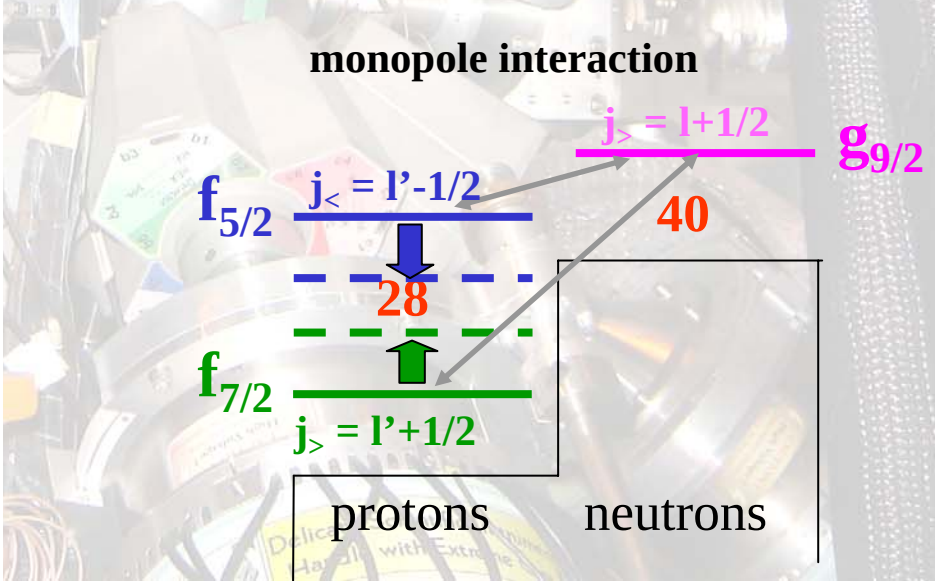
Beyond ^{68}Ni by Coulomb excitation with RIBs

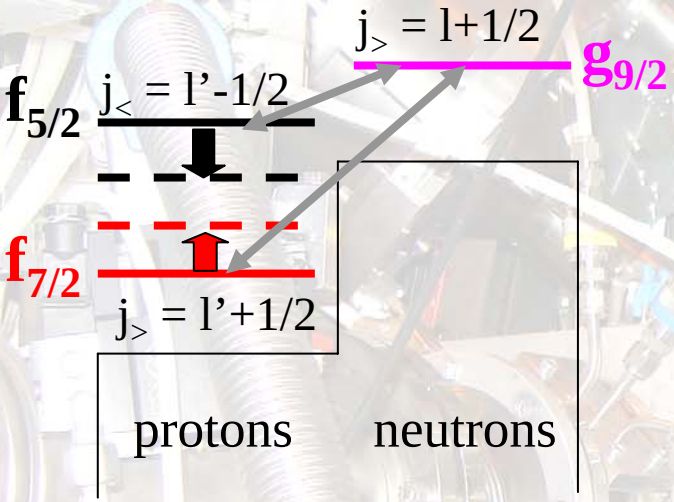
	Zn66	Zn67	Zn68	Zn69	Zn70	Zn71	Zn72	Zn73	Zn74	Zn75	Zn76	Zn77	Zn78	Zn79	Zn80	Zn81
	0+ 27.9	5/2- 4.1	0+ 18.8	56.4 m 1/2- β	5E+14 y 0+ 0.6	2.45 m 1/2- β	46.5 h β	23.5 s (1/2)- β	95.6 s β	10.2 s (7/2+) β	5.7 s β	2.08 s (7/2+) β	1.47 s β	995 ms (9/2+) β n	0.545 s β n	0.29 s β n
	Cu65 3/2- 30.83	Cu66 5.088 m 1+ β	Cu67 61.83 h 3/2- β	Cu68 31.1 s β	Cu69 2.85 m 3/2- β	Cu70 4.5 s (1+) β	Cu71 19.5 s (3/2-) β	Cu72 6.6 s (1+) β	Cu73 3.9 s β	Cu74 1.594 s (1+,3+) β	Cu75 1.224 s β n	Cu76 0.641 s β n	Cu77 469 ms β n	Cu78 342 ms β	Cu79 188 ms β n	Cu80
28	Ni64 0+ 0.926	Ni65 2.5172 h 5/2- β	Ni66 54.6 h 0+ β	Ni67 21 s (1/2-) β	Ni68 19 s 0+ β	Ni69 11.4 s β	Ni70 β	Ni71 1.86 s β	Ni72 2.1 s 0+ β	Ni73 0.90 s β	Ni74 1.1 s 0+ β	Ni75	Ni76 0+	Ni77	Ni78 0+	
	Co63 27.4 s (7/2)- β	Co64 0.30 s 1+ β	Co65 1.20 s (7/2)- β	Co66 0.23 s (3+) β	Co67 0.42 s (7/2-) β	Co68 0.18 s β	Co69 0.27 s β	Co70	Co71	Co72						

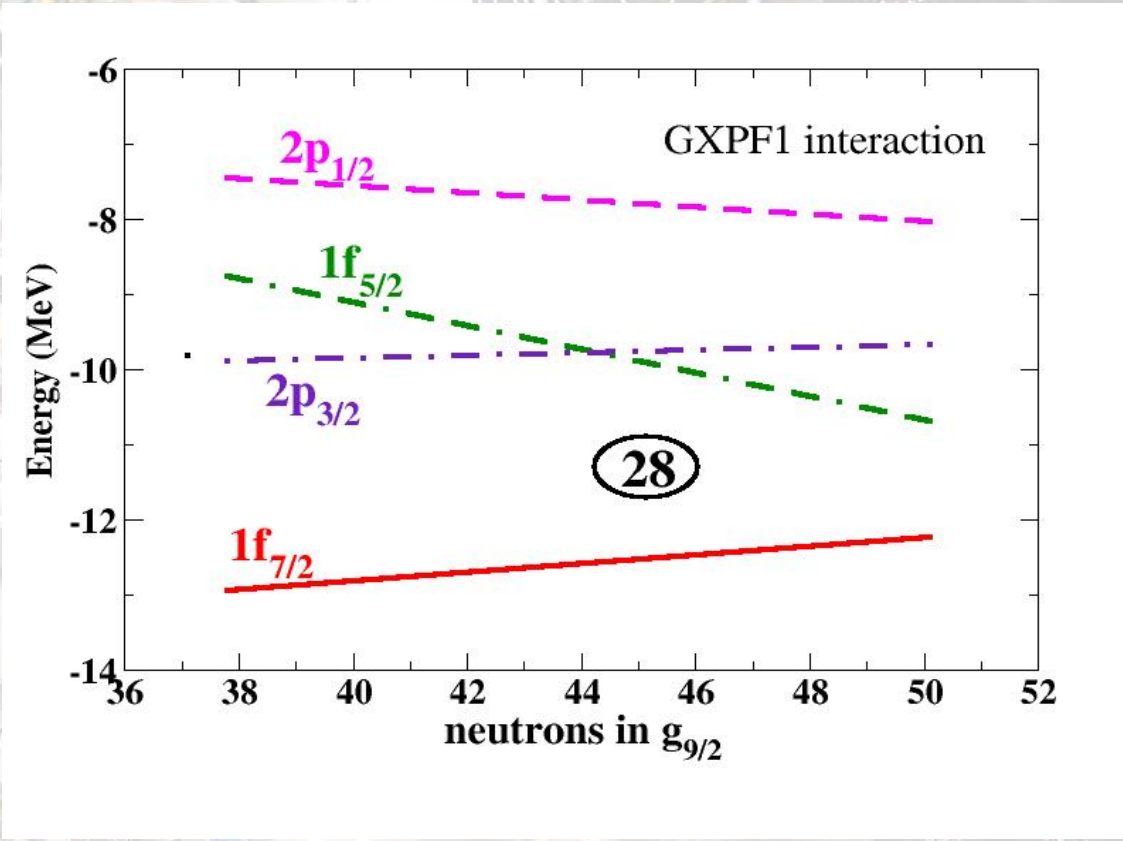
36 38 40 42 44 46 48 50

★ measured by Coulex with RIBs

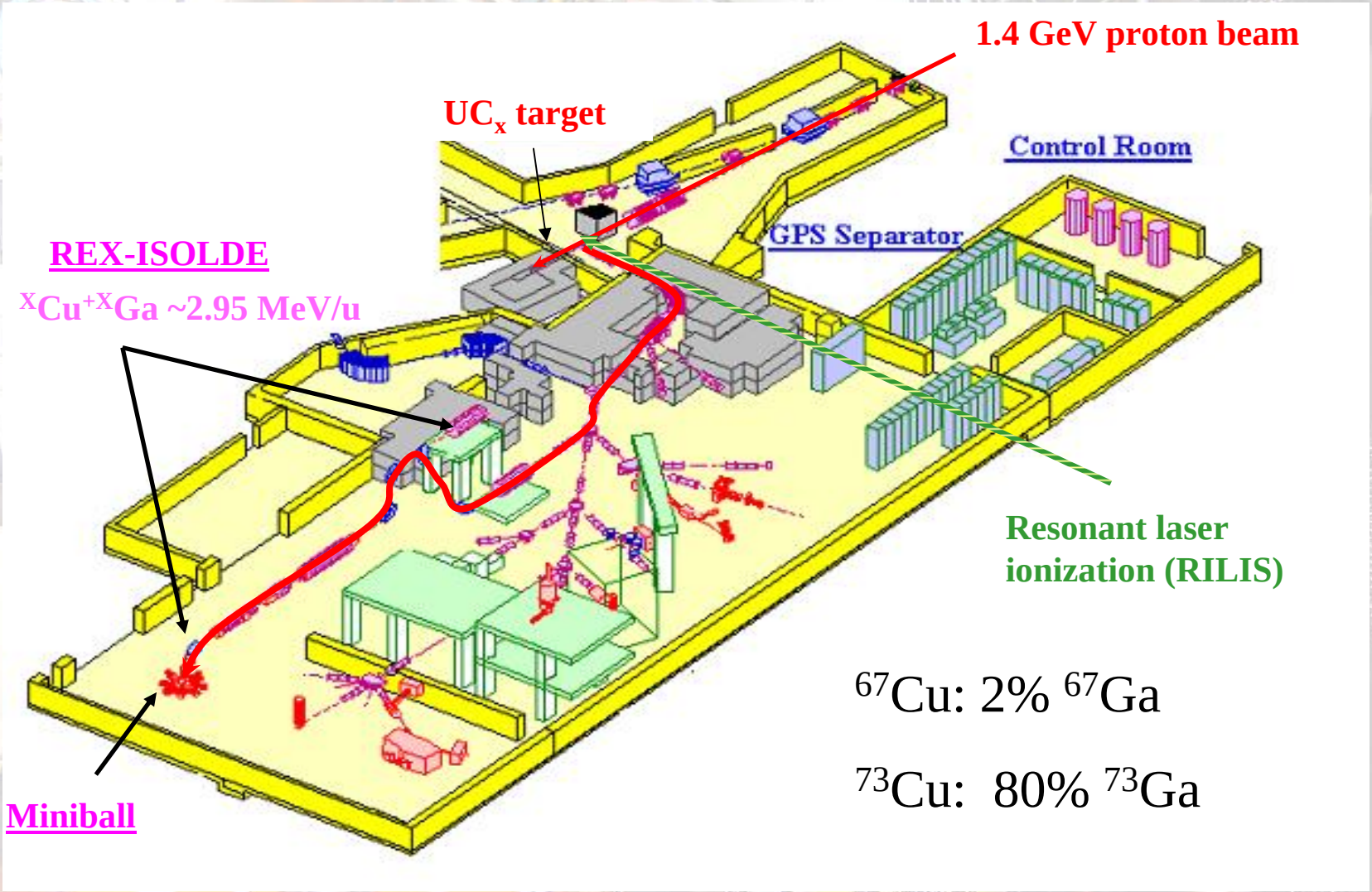





$j_> = l+1/2$
$g_{9/2}$
$f_{5/2}$
$j_< = l'-1/2$
$f_{7/2}$
$j_> = l'+1/2$
protons
neutrons


GXPF1 interaction
$2p_{1/2}$
$1f_{5/2}$
$2p_{3/2}$
28
$1f_{7/2}$
Energy (MeV)
neutrons in $g_{9/2}$
-6
-8
-10
-12
-14
36
38
40
42
44
46
48
50
52

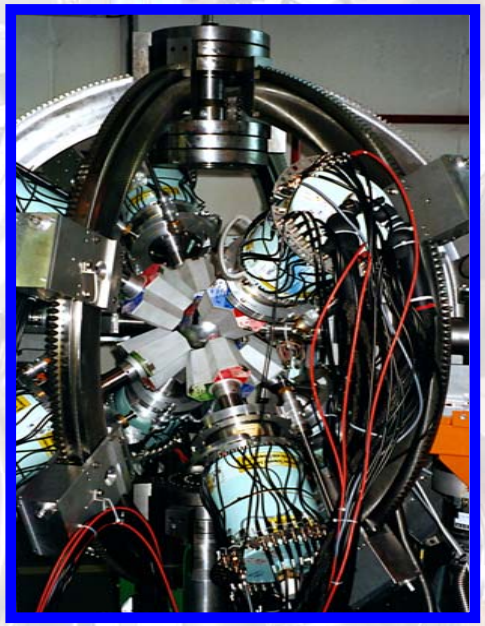
Radioactive beams of ^{67,69,71,73}Cu @ISOLDE



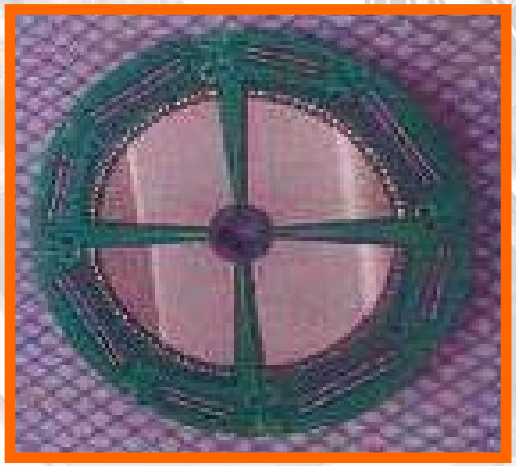
^{67}Cu: 2% ^{67}Ga

^{73}Cu: 80% ^{73}Ga

Experimental set-up for Coulex @REX-ISOLDE

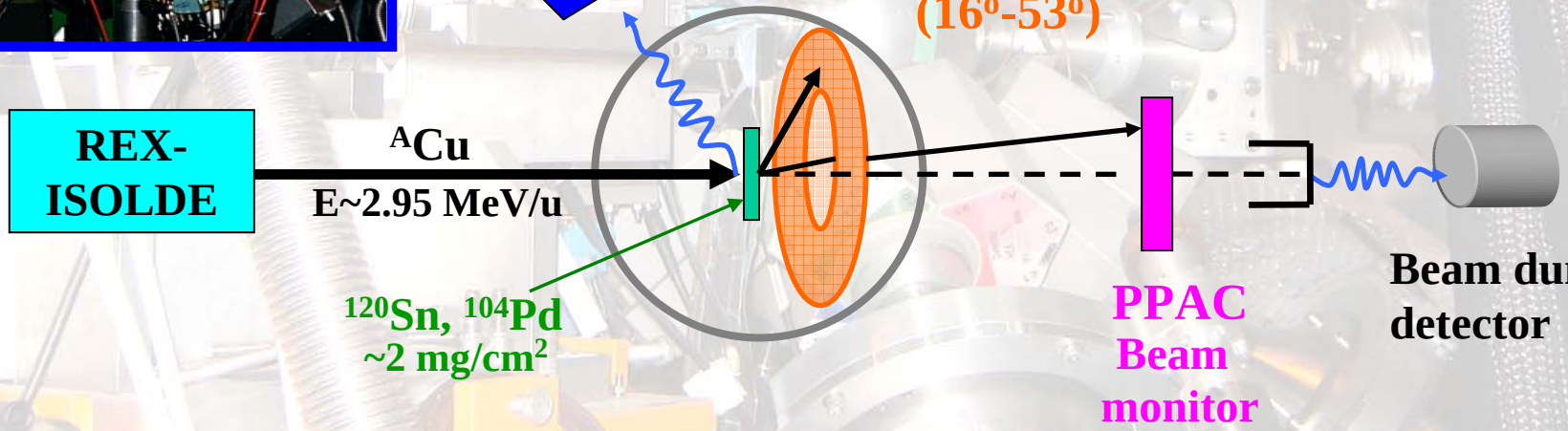


Miniball



- 4 quadrants
- 16 annular strips (θ)
- 24 sector strips (ϕ)

DSSD detector
(16º-53º)



v/c ~ 7% ➔ Doppler correction of the γ-rays on an event-by-event mode by using the segmentation of the particle and γ-detectors.