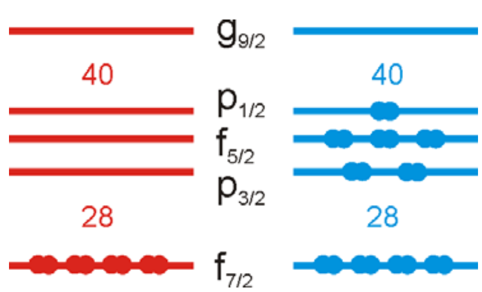
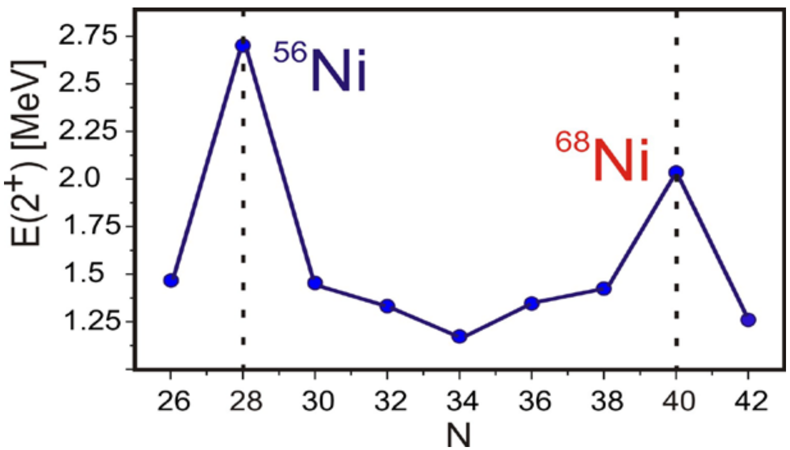
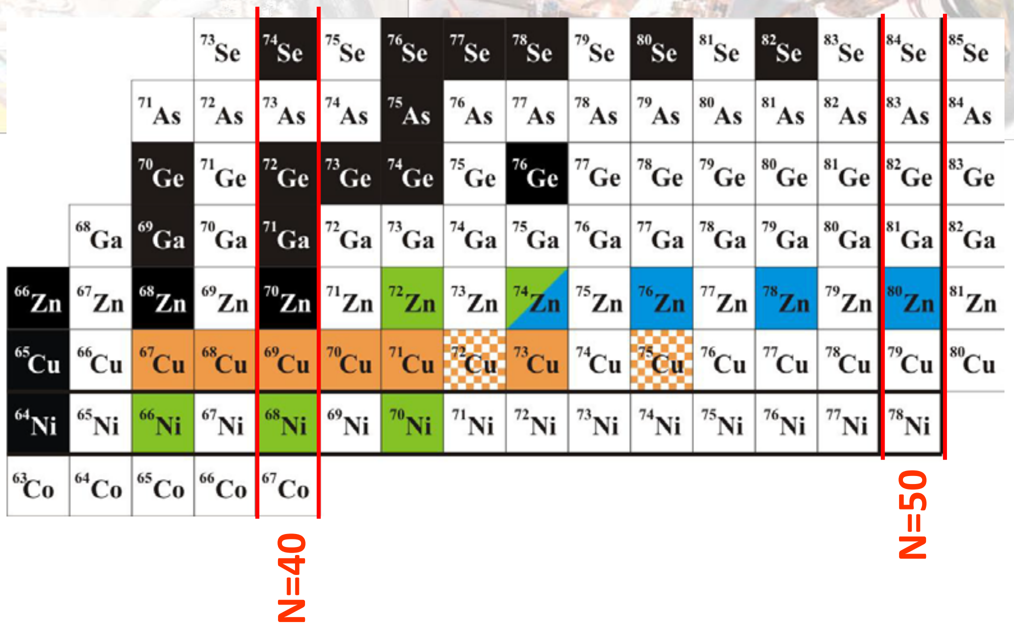
Coulomb Excitationof Isomeric states of ^{70}Cu

ElisaRapisarda, IKS K.U. Leuven

N=40 and Coulexof the Cu isotopes







➢ n-rich Cu isotopes provide an excellent means for testing the proton-neutron residual interaction in this mass -region;

✓ **high E(2$^+$) in ^{68}Ni** **(R. Broda*et al.*, PRL 74 (95) 868)**

✓ **proposed new magic number N=40**

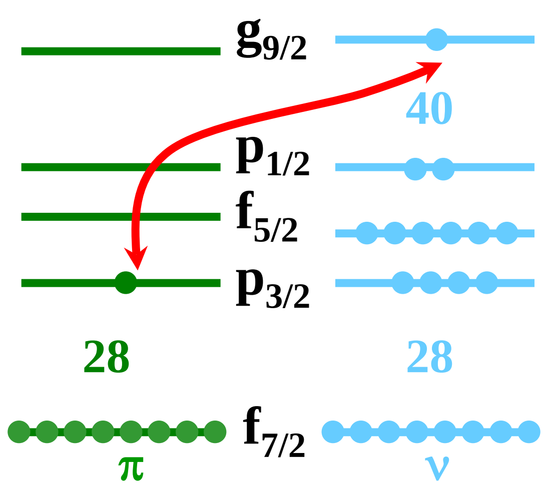
❑ 2005: Coulomb excitation of odd-odd ^{68,70}Cu;

❑ 2006: Coulomb excitation of odd-mass ^{67,69,71,73}Cu.

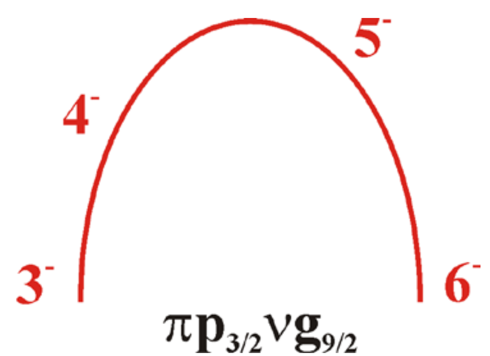
The odd – odd ^{70}Cu

- the low-energy level schemes dominated by multiplets originating from the coupling of the odd proton with the odd neutron $\pi p_{3/2} \otimes \nu g_{9/2}$ = $3^-, 4^-, 5^-, 6^-$ or $\pi p_{3/2} \otimes \nu p_{1/2}$ = $1^+, 2^+$

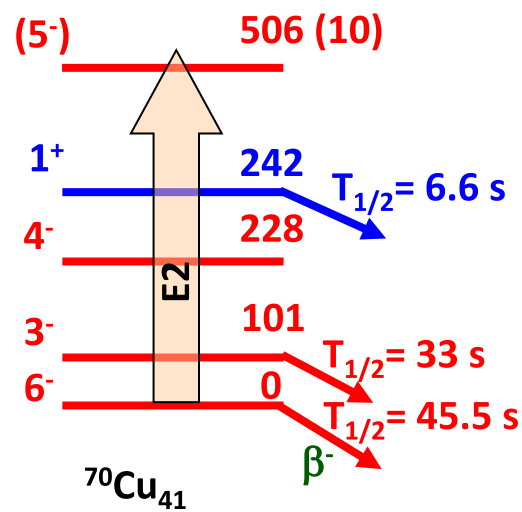
- B(E2) values within the states of the $\pi p_{3/2} \otimes \nu g_{9/2}$ multiplet offers important information about the *p-n* residual interaction across N=40.



$^{70}Cu_{41}$



V. Paar Nucl.Phys.A331(1979)16



^{70}Cu: J. Van Roosbroeck et al., PRL92(2004)112501, J. Van Roosbroeck et al., PRC69(2004)034313.

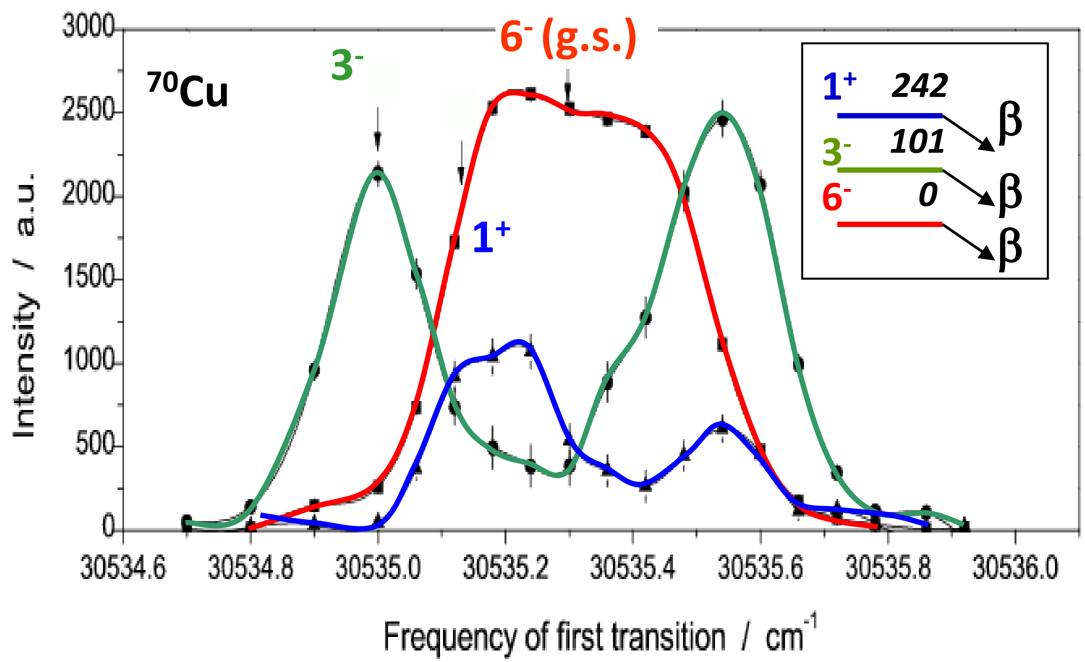
^{70}Cu: J. D. Sherman et al., Phys.Lett. B67(1977)275

^{68,70}Cu: I. Stefanescu et al., Phys.Rev. Lett 98(2007)122701

IsomericBeamsfrom REX-ISOLDE

- technique based on in-source laser spectroscopy
(Ü. Köster et al., NIM B, 160, 528(2000); L. Weissman et al., PRC65, 024315(2000)).

- set the laser frequency to select and maximize the production of the isomer of interest.



J. Van Roosbroeck et al., PRL92(2004)112501

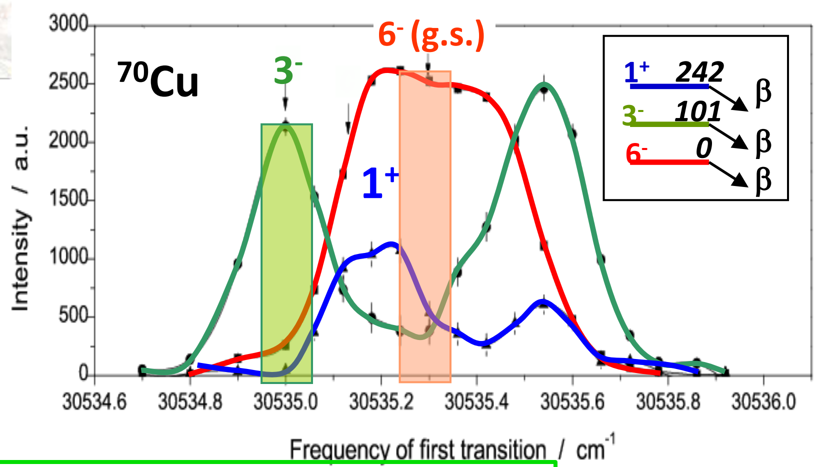
+ postacceleration by REX-ISOLDE

Experimentaldetails

^{70}Cu on ^{120}Sn

Beam energy: **2,83 MeV/u**

Beam Intensity: **5 X 10^{5}pps**



^{70}Cu/^{70}Ga = 80%/20%

^{70}Cu:

6$^-$→ 86%

3$^-$→ 7%

1$^+$ →7%

Isomeric Composition determined from characteristic beta decay lines

^{70}Cu/^{70}Ga = 50%/50%

^{70}Cu:

6$^-$→ 72%

3$^-$→ 25%

1$^+$ →less than 3%

Inclusive excitation cross-section

Inclusive excitation cross-section

disentangle

σ (6$^-$→ XXX) andσ (3$^-$→ XXX)

^{68,70}Cu: I. Stefanescu et al., Phys.Rev. Lett 98(2007)122701

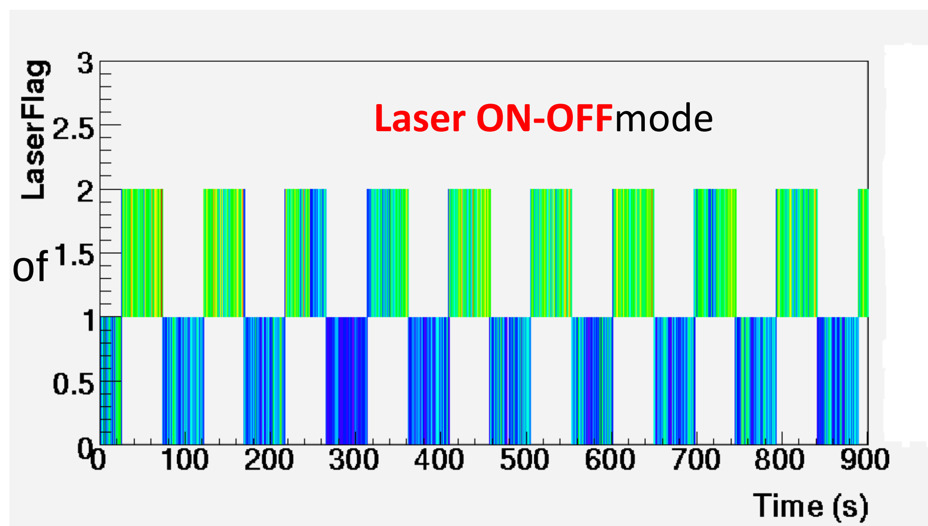
^{70}Ga contamination

The separator is not able to separate ^{70}Cu from ^{70}Ga → ^{70}**Ga** and ^{70}**Cu** impinges both on target

Laser ON – Laser OFF to disentangle Cu interaction from Ga interactions

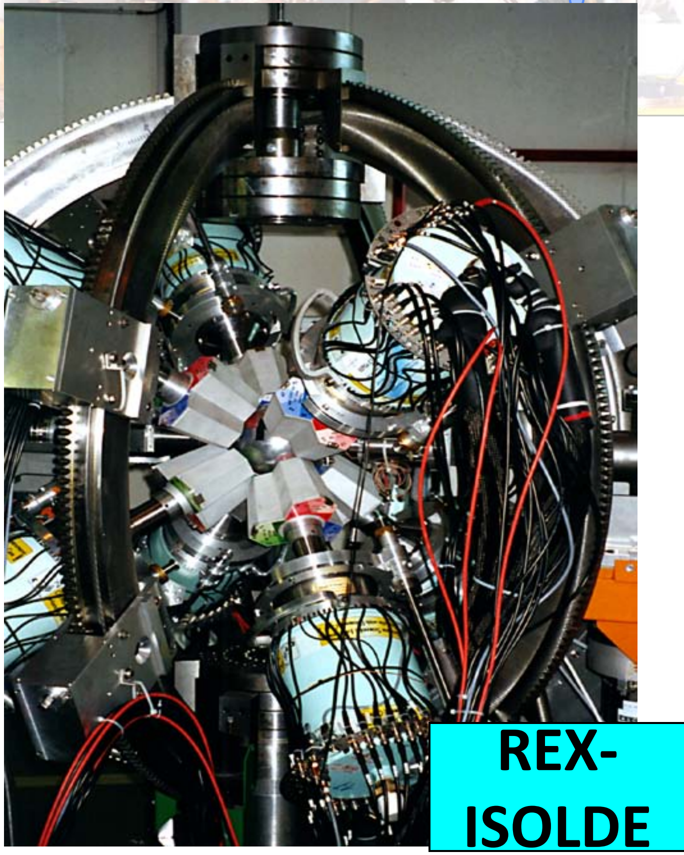
Laser ON ^{70}Cu + ^{70}Ga

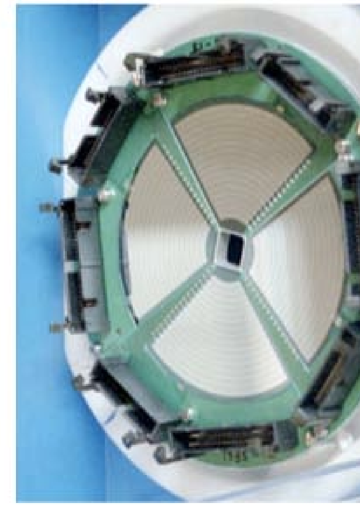
Laser OFF ^{70}Ga

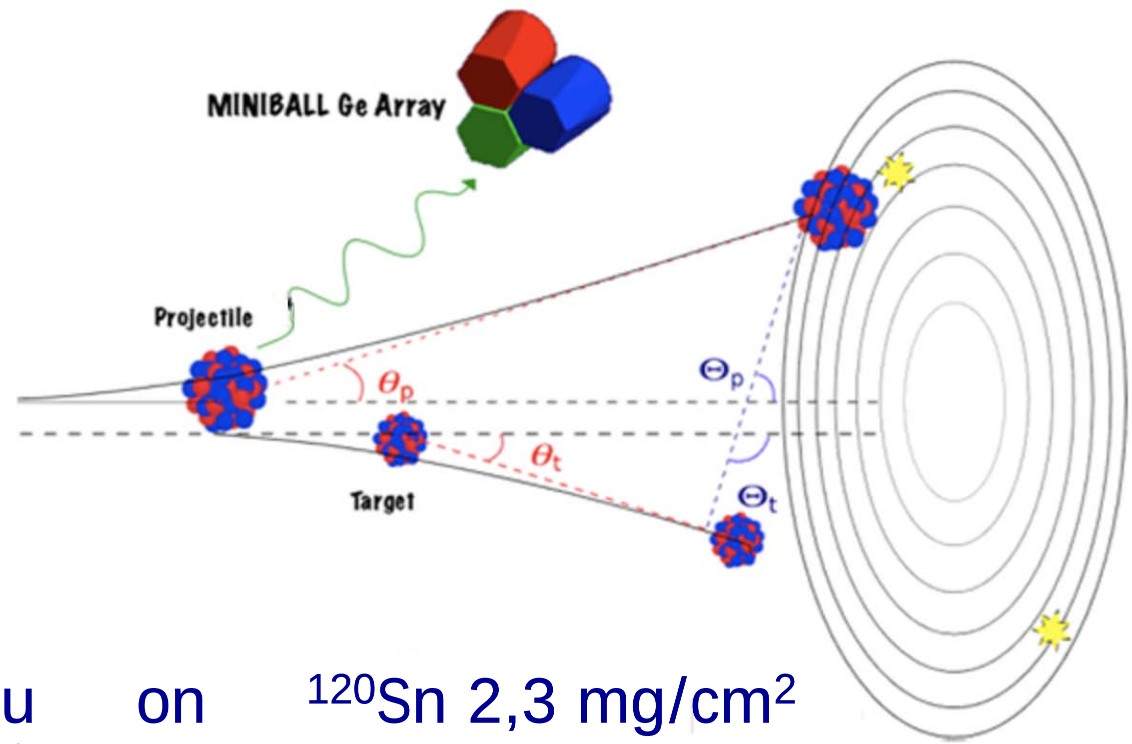


Gacontribution can be precisely substractedprovided a precise normalization of Laser ON laser OFF run

ExperimentalSetup

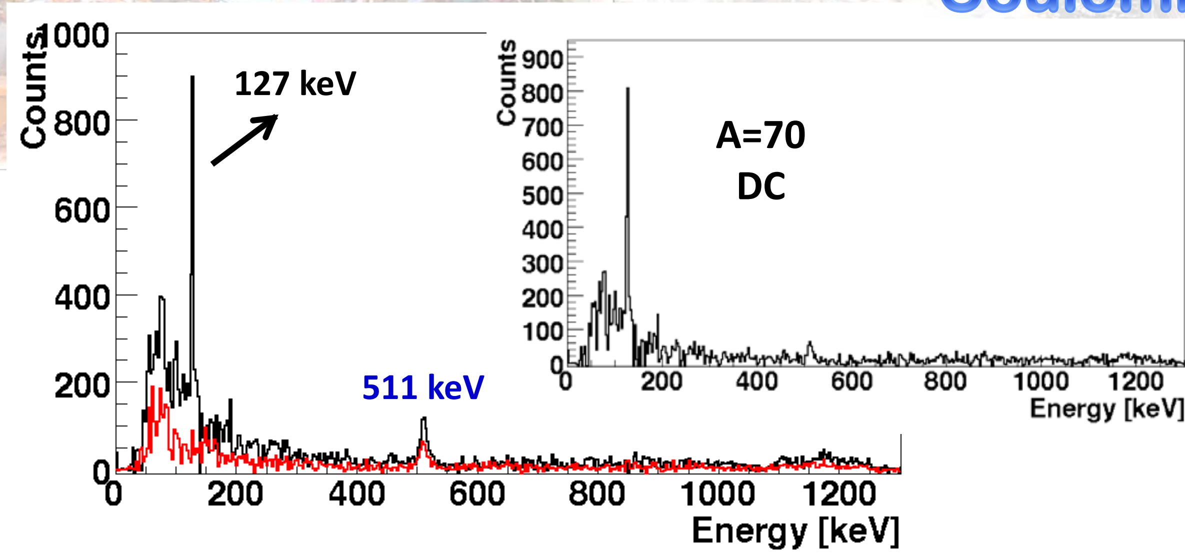


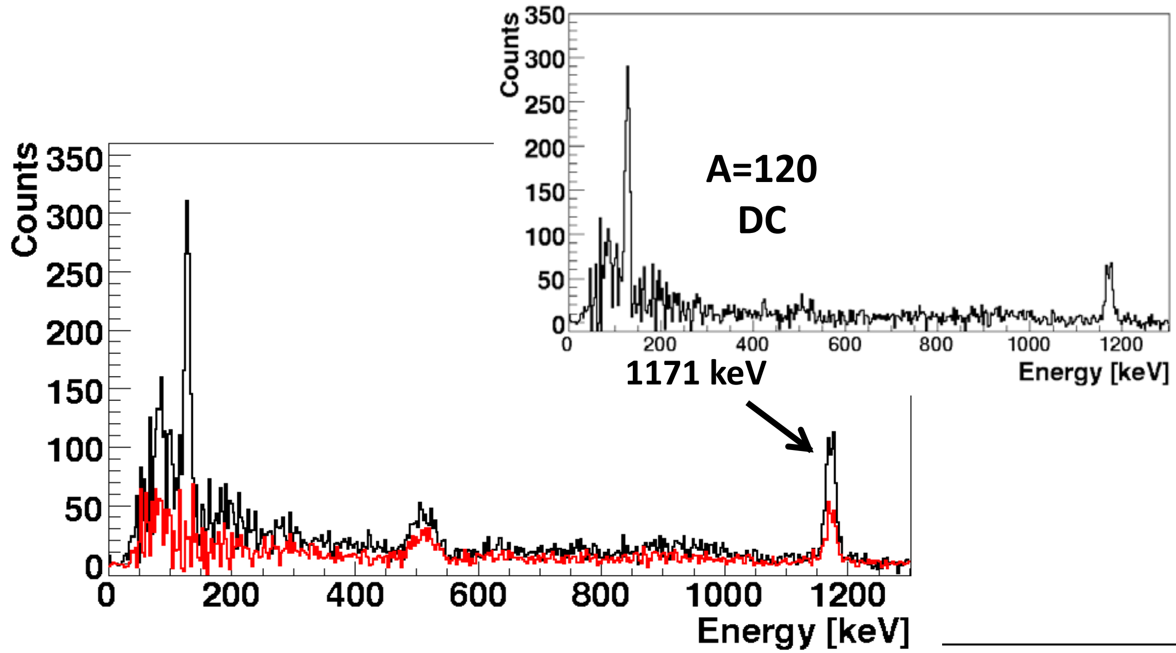


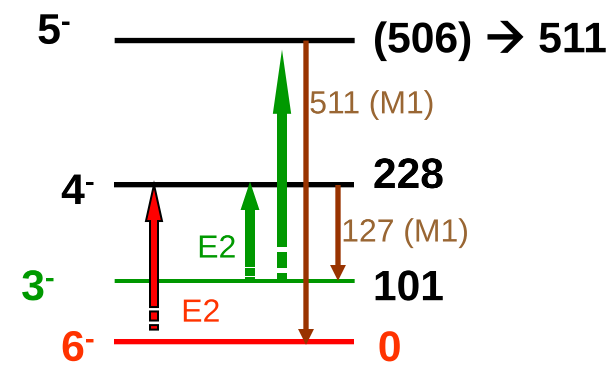


^{70}Cu 2,9 MeV/u on ^{120}Sn 2,3 mg/cm^2

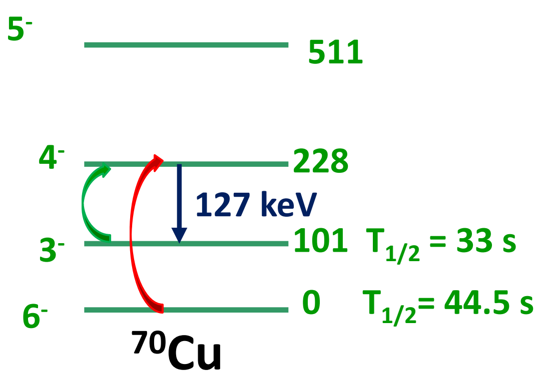
Coulomb Excitationof $^{70,gs}Cu$ and $^{70,m1}Cu$

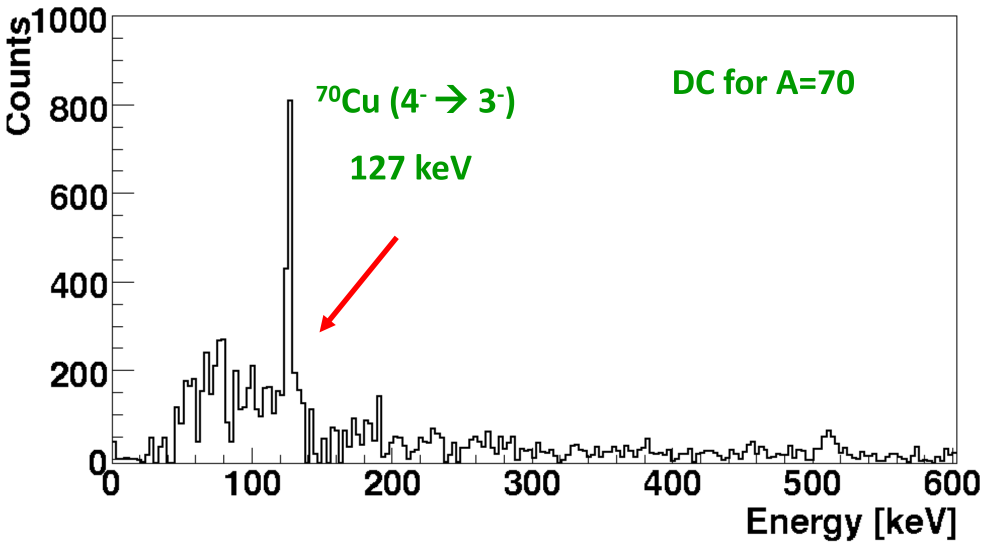






Cross Section: 127 KeV





Measurement of the **($4^- \rightarrow 3^-$)** cross section in both experiments

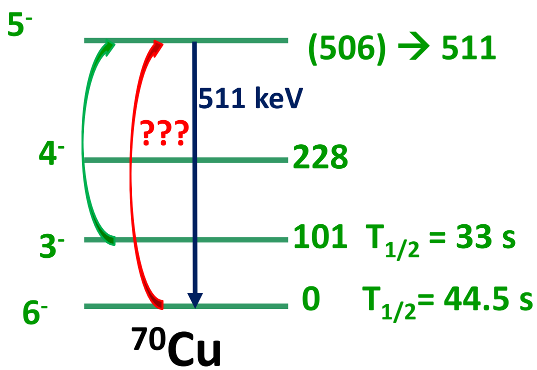
Isomeric Composition of the ^{70}Cu beam is known

Disentangle the σ **($6^- \rightarrow 4^-$)** andσ **($3^- \rightarrow 4^-$)**

- CLX code
- Matrix element = 0.23(3) eb
- B(E2, $3^- \rightarrow 4^-$) = 73(10) e^2 fm^4

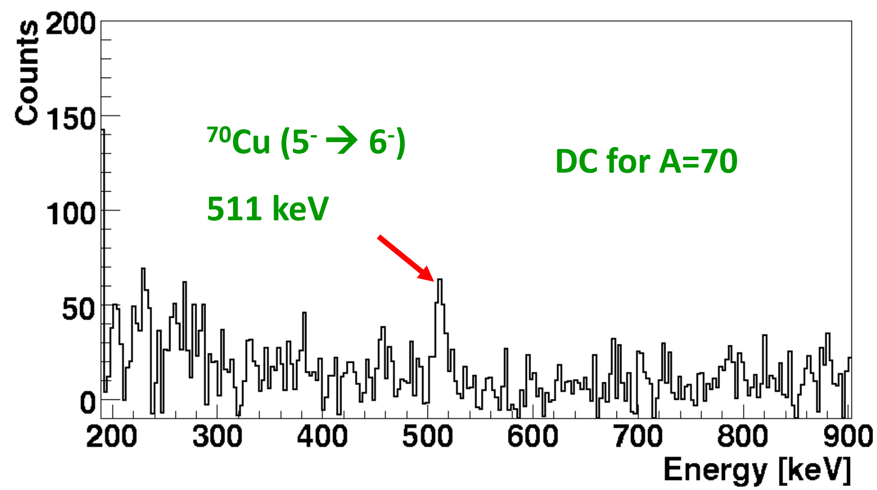
- CLX code
- Matrix element 0.30(4) eb
- B(E2, $6^- \rightarrow 4^-$) = 69(9) e^2 fm^4

Cross-Section 511 KeV



Assuming only **(3^- → 5^-) excitations**

Challenge to measure

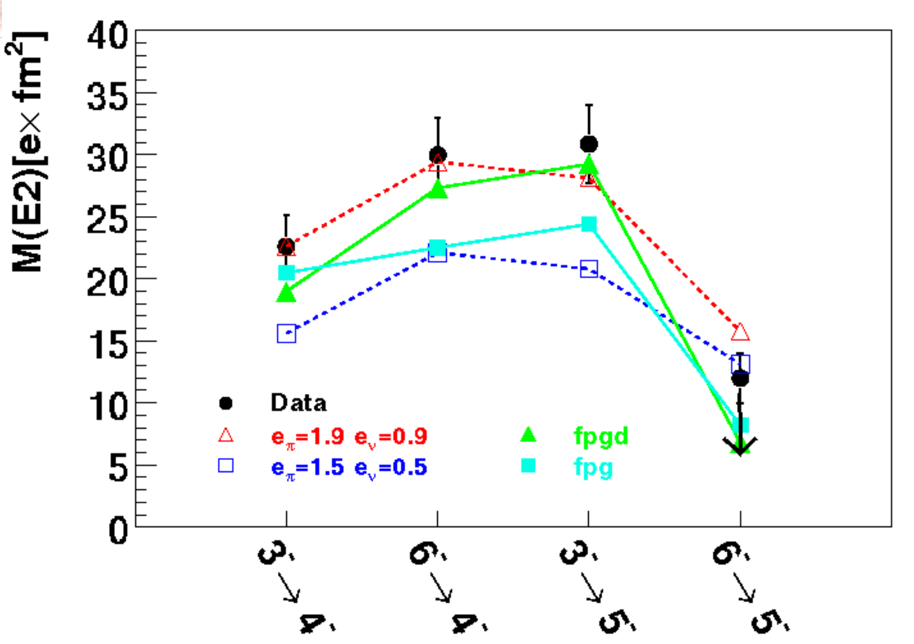


- CLX code
- Matrix element 0.308(19) eb
- B(E2, 3^-→ 5^-) = 136(15) e^2 fm^4

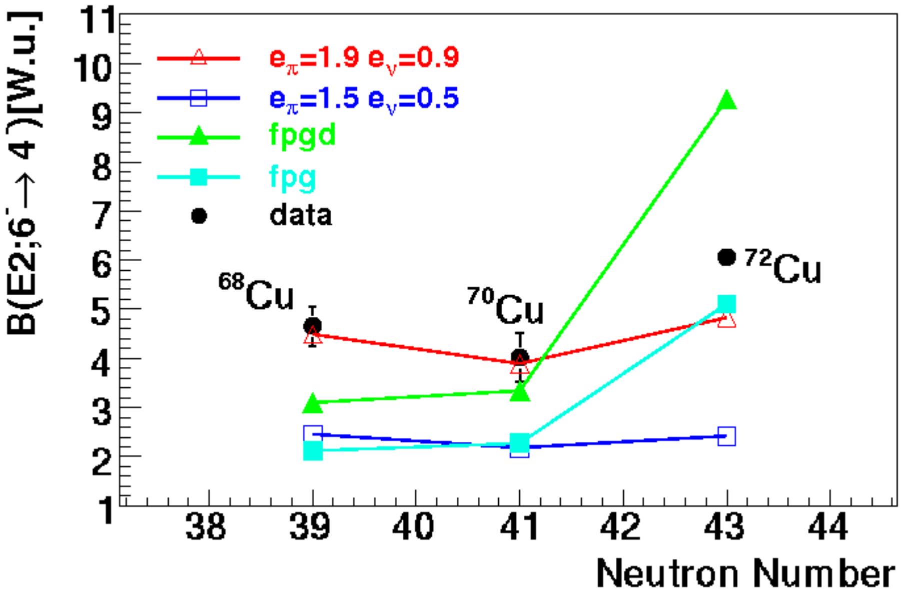
Upper Limit

Shell Models: comparison

Large Shell-Model calculations with ANTOINE code



Systematics of the 6⁻→ 4⁻ transition



Calculationsby N. Smirnova

- realistic interaction
(M. Hjorth-Jensen et al. , Phys.Rep.26(2004)
- model space is1f5/2 2p3/2 2p1/2 1g9/2 outside the ^{58}Ni inert core;

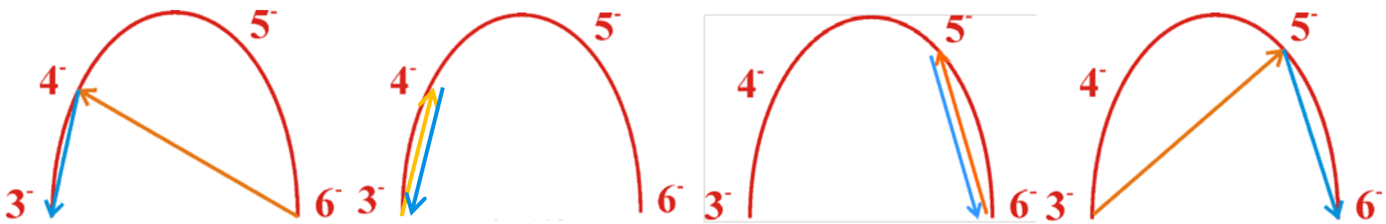
Calculationsby K. Sieja

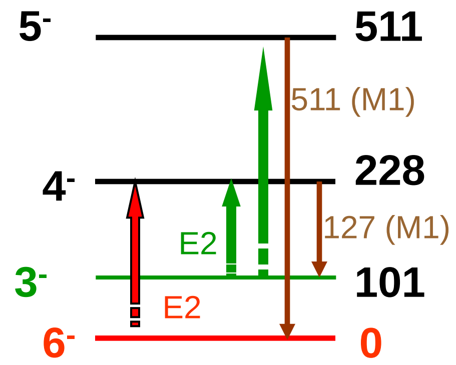
- hybridinteraction(S.Lenzi et al., PRC82, 05430(2010)) + evolution of the proton gap from ^{68}Ni to ^{78}Ni,
- model space is1f7/2 1f5/2 2p3/2 2p1/2 for protons and 1f5/2 2p3/2 2p1/2 1g9/2 1d5/2 for neutrons outside the ^{48}Ca inert core;

Summary and more

• the observation of the 511 KeV decaying transition fixes the energy, spin and parity assignment of the 5^- member of the $\pi p_{3/2} \otimes \nu g_{9/2}$ multiplet;

•E2 transitions within the multiplet of states have been investigated





• For these transitions the following B(E2) values have been measured:

- $B(E2, 6^- \rightarrow 4^-) = 69(9)\ e^2\,fm^4$
- $B(E2, 3^- \rightarrow 4^-) = 73(10)\ e^2\,fm^4$
- $B(E2, 6^- \rightarrow 5^-) \leq 11(2)\ e^2\,fm^4$
- $B(E2, 3^- \rightarrow 5^-) = 136(15)\ e^2\,fm^4$

... What we have learned

• Comparison withLargeShellModelCalculationsreveals:

✓largepolarizationof the ^{56}Ni core in ^{70}Cu,

✓the *fpgd*modelspaceisnecessary;

• from systematic of n-rich Cu isotopes:

✓ enhanced collectivity is predicted in ^{72}Cu not experimentally observed,

✓the role of the d5/2 orbital deserves further investigation

Collaboration

- **IKS Leuven, Belgium -** I. Stefanescu, J. Diriken, N. Bree, M. Huyse, O. Ivanov, N. Patronis, J. Van de Walle, P. Van Duppen, B. Bastin
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- **CSNSM Orsay, France -** G. Georgiev, E. Fiori, R. Lozeva
- **IKP Köln, Germany -** N. Warr, A. Blazhev, J. Jolie, M. Kalkuehler, M. Seidlitz
- **TU München, Germany -** V. Bildstein, R. Gernhauser, Th. Kröll, T. Behrens, R. Krücken, P. Maierbeck, K. Wimmer
- **University of Camerino, Italy -** D.L. Balabanski, K. Gladnishki, G. Lo Bianco, S. Nardelli
- **Warsaw University, Poland -** J. Iwanicki, K. Hadynska, K. Wrzosek, M. Zielinska, J. Srebrny
- **NCSR Demokritos, Greece -** S. Harissopulos, A. Lagoyannis, Th. Konstantinopoulos
- **University of Liverpool, UK -** P. Butler
- **Universiteit Ghent, Belgium -** K. Heyde, A. De Maesschalck, N. Smirnova
- **CERN, Geneva, Switzerland -** J. Cederkäll, A. Ekström, L.M. Fraile, P. Delahaye, V. Fedoseev, U. Köster, B. A. Marsh,T. Sieber, D. Voulot, F. Wenander

and the ISOLDE and Miniball collaborations

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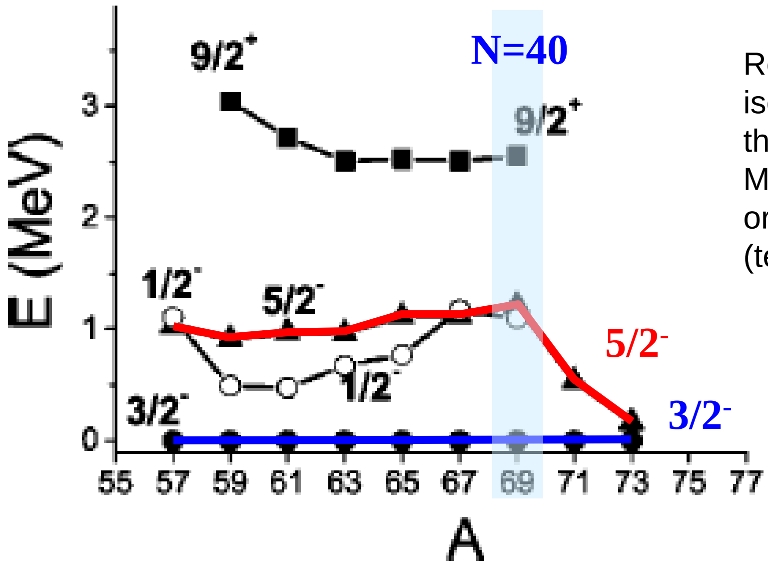
Experiment

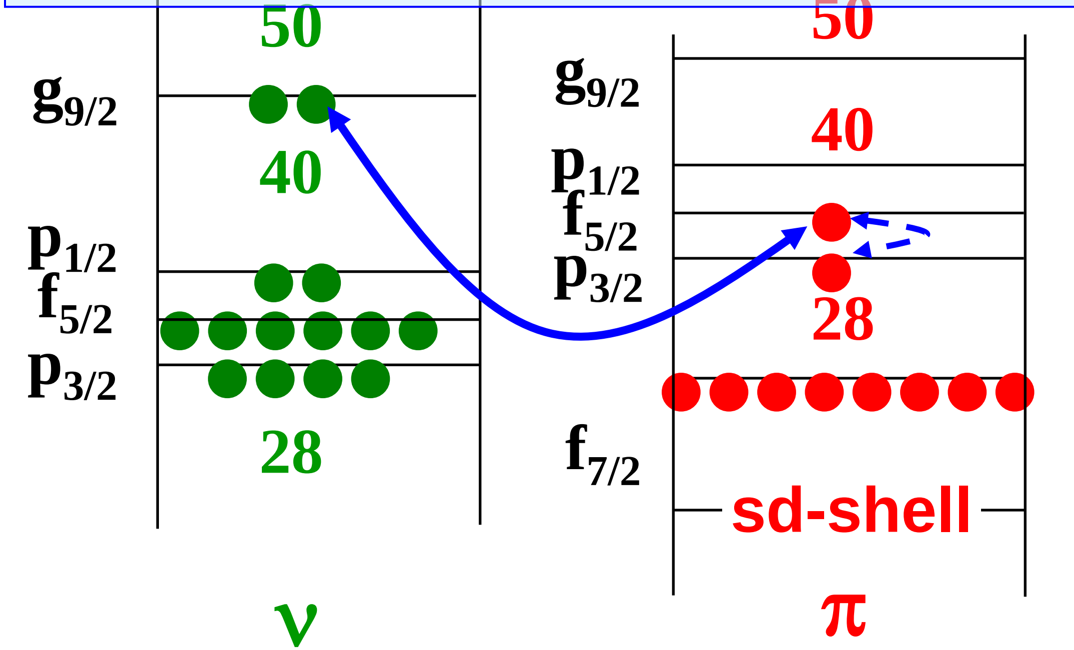


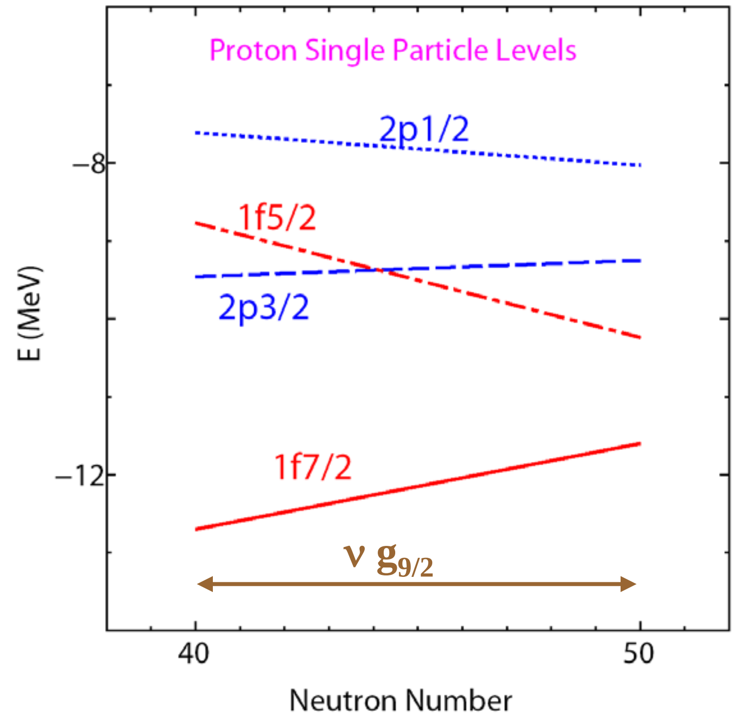
Results of b-decay studies in the neutron rich $^{69-73}$Cu isotopesrevealed a dramatic and suddenlowering of the $\pi 1f_{5/2}$with the increasedoccupancy of the $\nu 1g_{9/2}$orbital. Referred to as MONOPOLE MIGRATION, thisenergy shift was interpreted as originatingfrom the residualproton-neutroninteraction. (tensorforcedue to one-pion exchange process)

➤ Monopole interaction: Cu

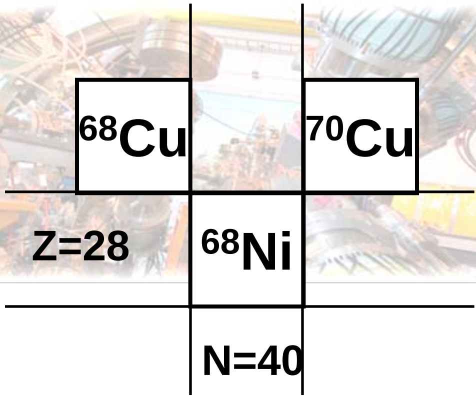
T. Otsuka

S. Franchoo et al., PRL81 (1998) 3100, PRC64 (2001) 054308
N. Smirnova et al., PRC69 (2004) 044306





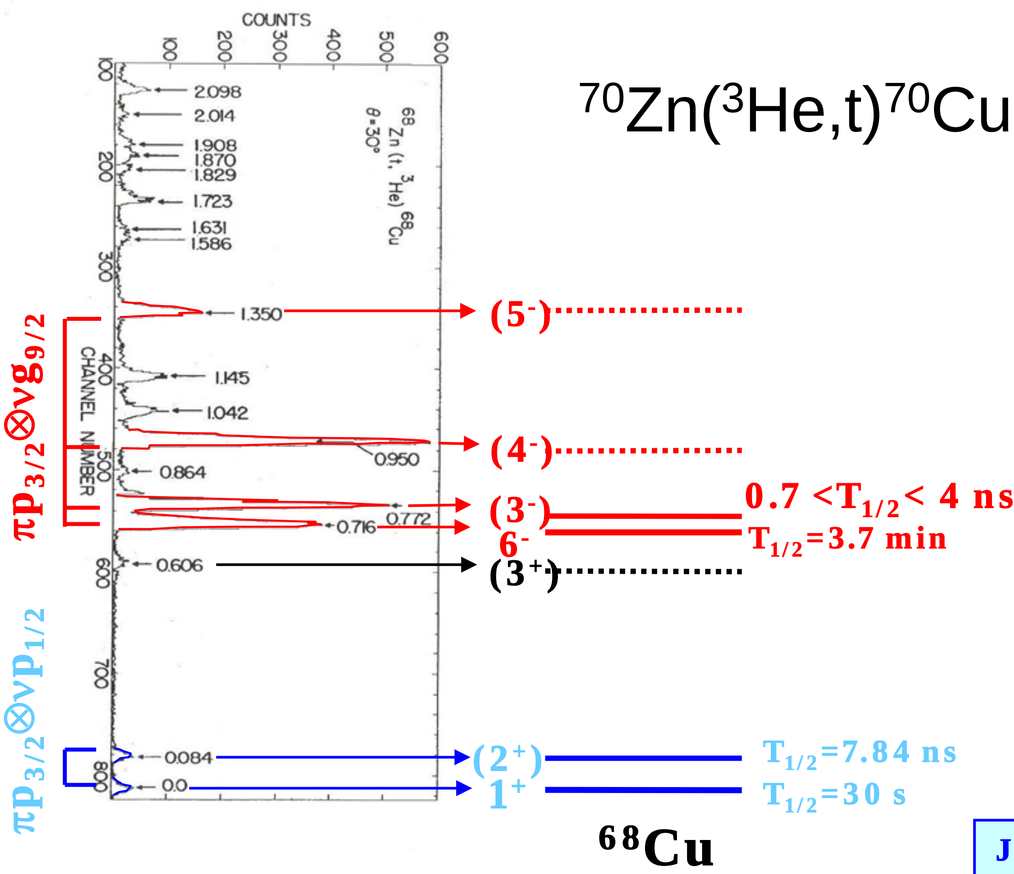
Neutron-rich even-A Cu isotopes - ^{68,70}Cu -

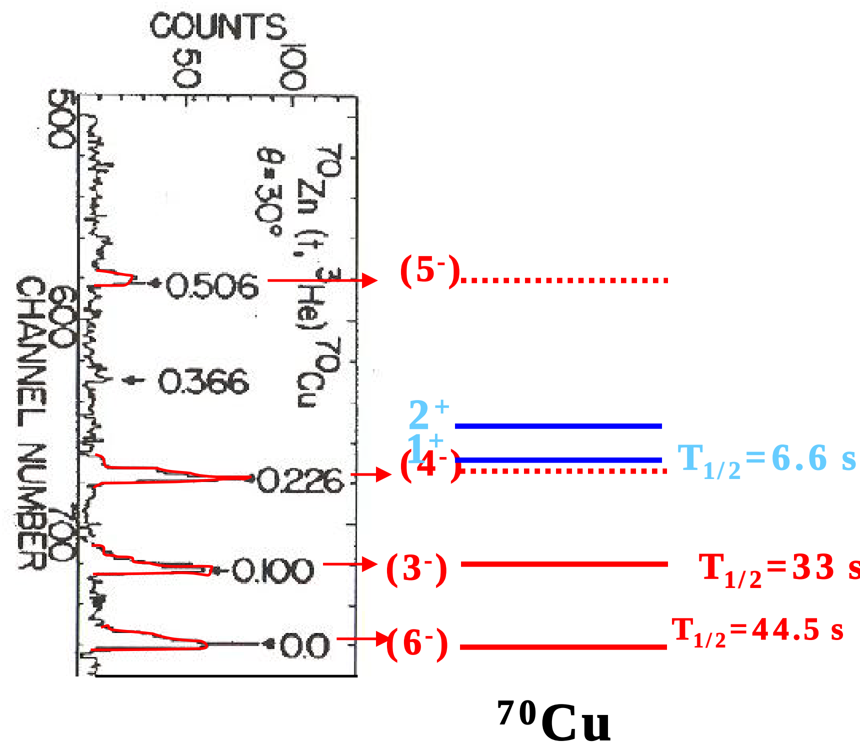


$\pi p_{3/2} \otimes \nu p_{1/2}$ ($J^{\pi}=1^{+}, 2^{+}$)

$\pi p_{3/2} \otimes \nu g_{9/2}$ ($J^{\pi}=3^{-}, 4^{-}, 5^{-}, 6^{-}$) ⇒ **Isomers**

^{70}Zn(^{3}He,t)^{70}Cu





T. E. Ward et al., PR88, 1802(1969)
L. Hou et al., PRC68, 054306(2003)

J.D. Sherman *et al.* PLB67 (77) 257
T. Ishii et al., Jaeri-Review, 2002-029, 25
J. Van Roosbroeck et al., PRL92(2004)112501
J. Van Roosbroeck et al., PRC69(034313).