E2 Strengths in ^{98}Zr

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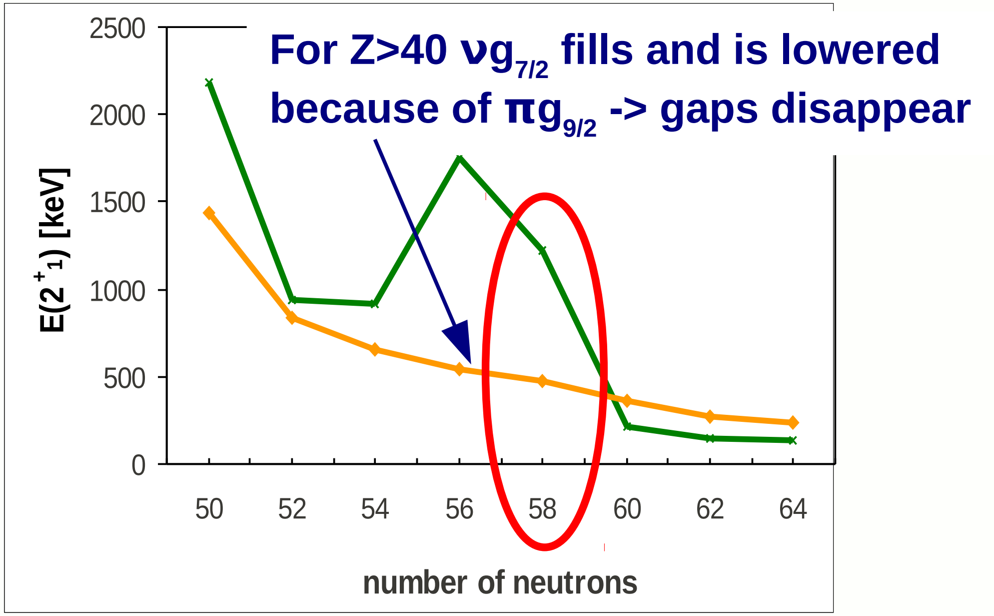
Aims of the Experiment

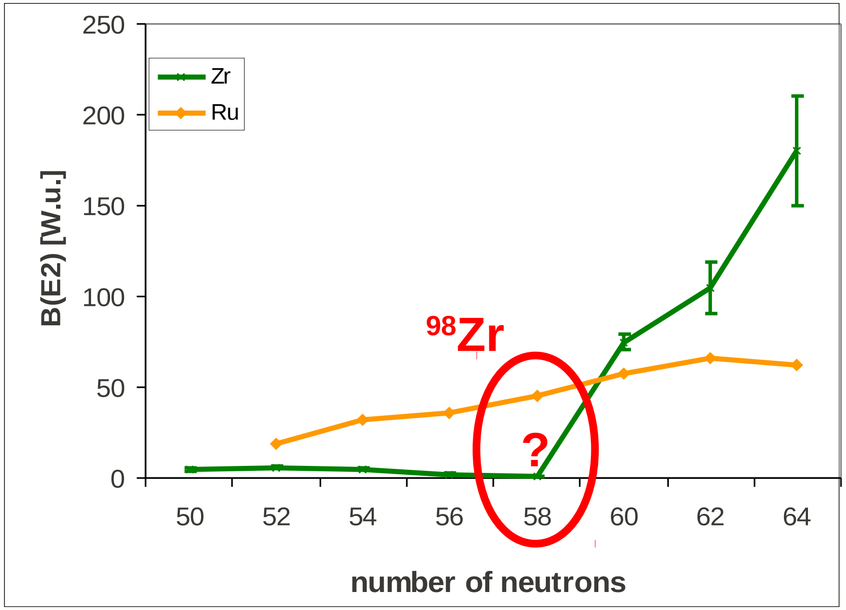
Coulex of ^{98}Zr using GRETINA & CHICO2

- At the brink of deformation past Z=56;
  testing collectivity at Z=58 by measuring E2 to the 2_1^+
- Weak or strong coupling?
  Is the mixed-symmetry one-phonon 2^+ state excited;
  B(E2) excitation strength will give first hint on structure
- Collective (?) structure of ^{98}Zr already developed?
  Look at B(E2)s among higher-lying states,
  including low-lying 0^+s

1) $E(2_1^+)$ and $B(E2)$ Systematics

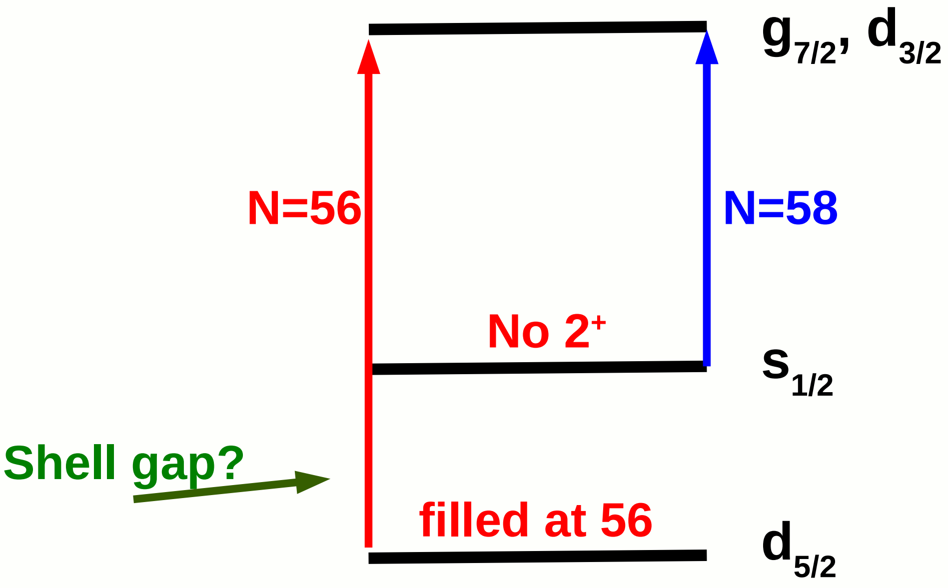
Are N=50, 56 *and* 58 „magic" (stabilized by Z=40)?


For Z>40 $\nu g_{7/2}$ fills and is lowered because of $\pi g_{9/2}$ -> gaps disappear



Weak coupling (p-n) was shown for Z~40, N<56 in prev. works

Assume it here -> $E(2_1^+)$ depends mainly on SPEs



B(E2) will show how important correlations are!

P-n Configuration Mixing

Simple picture: p-n 2-configuration mixing

fully p-n symmetric state: $2^+_{fs} = a_1 \cdot 2^+_n + b_1 2^+_p$

p-n mixed-symmetric state: $2^+_{ms} = a_2 \cdot 2^+_n - b_2 2^+_p$

protons and neutrons contribute about equally: good F-spin

$$|a_i| \approx |b_i|$$

imbalance in proton and neutron contributions: broken F-spin

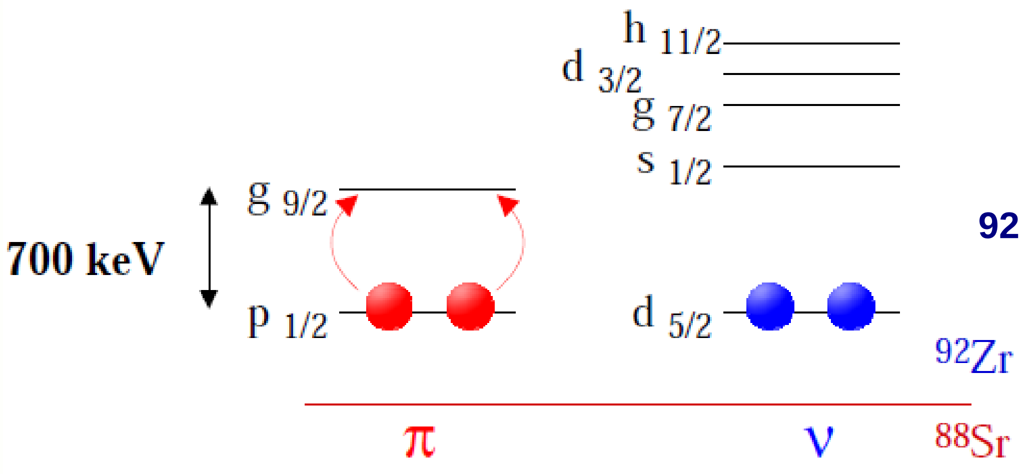
$$|a_i| \neq |b_i|$$

This is „Configurational Isospin Polarization”

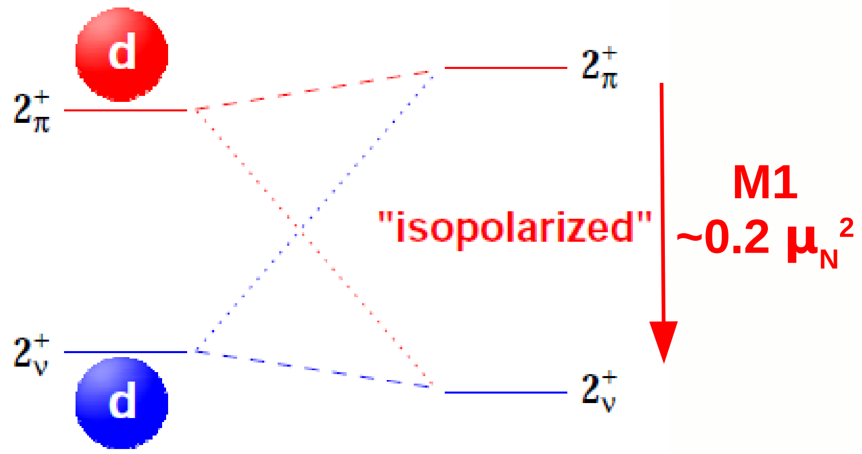
Based on Heyde/Sau, PRC 33, 1050 (1986)

2) (Mixed?)-p-n-Symmetry?

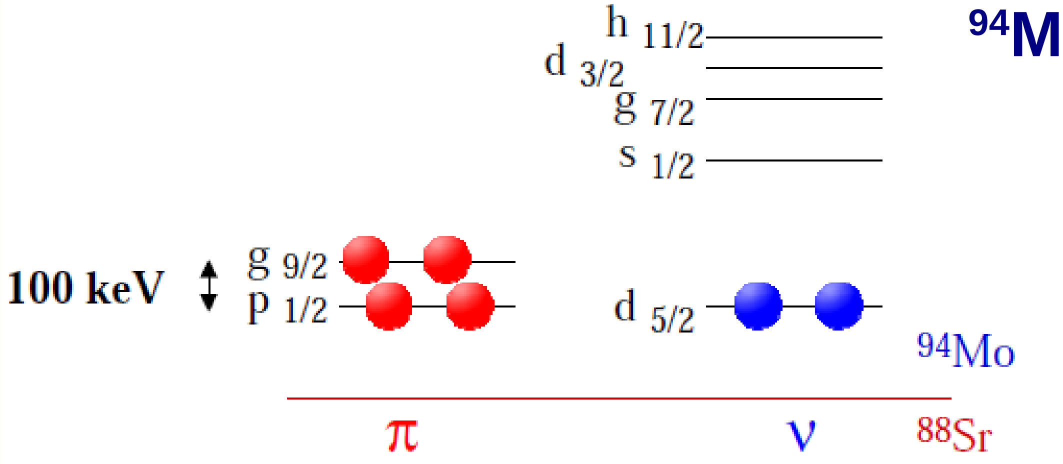
scheme for weak coupling

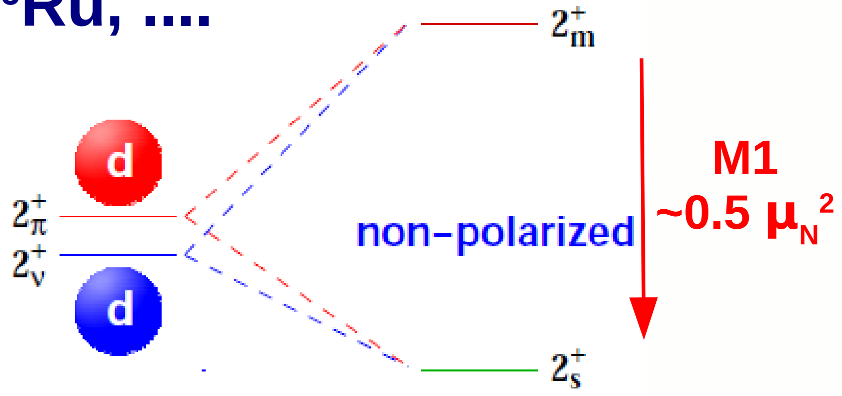


^{92,94}Zr



^{94}Mo, ^{96}Ru, ...



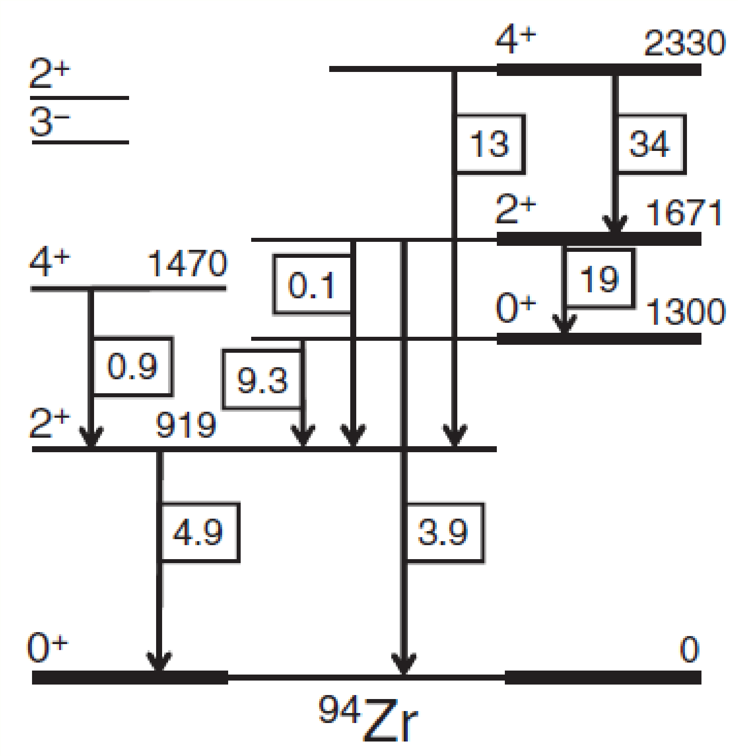


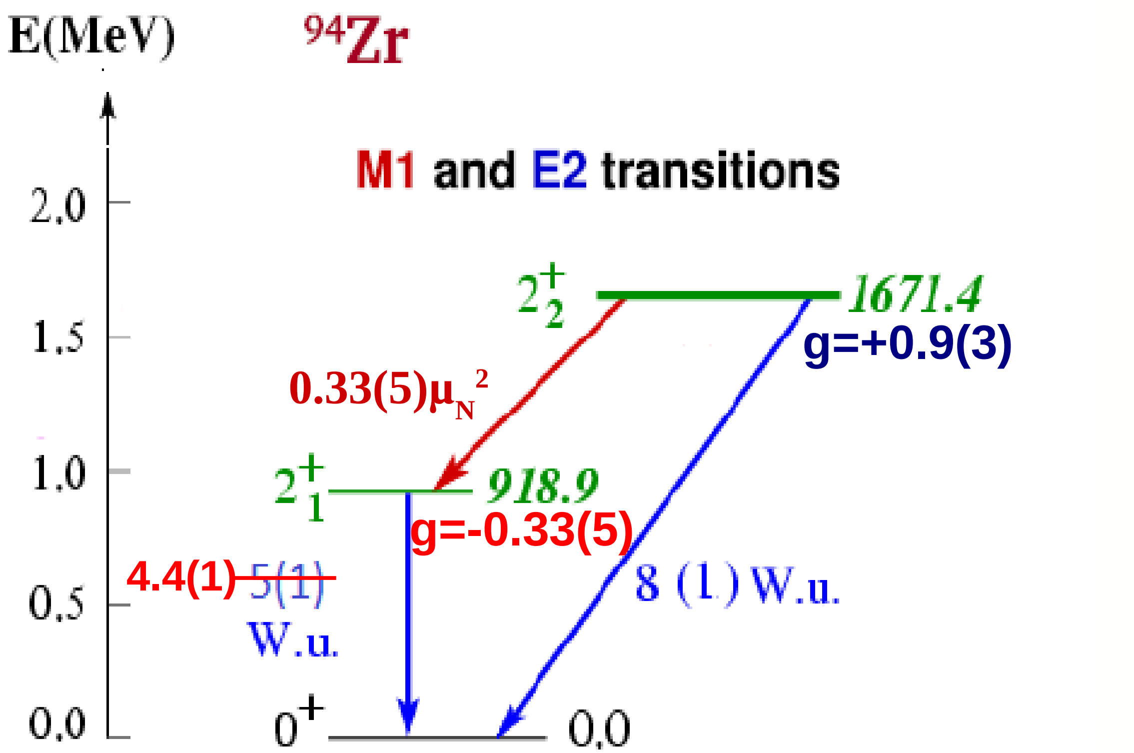
Magnetic Moments of both states should be sensitive to proton-neutron contents

MS and/or Shape Coex. in ^{94}Zr

A. Chakraborty et al., PRL 110, 032503 (2012)

„excited collective structure"
(or just proton-dominated structu



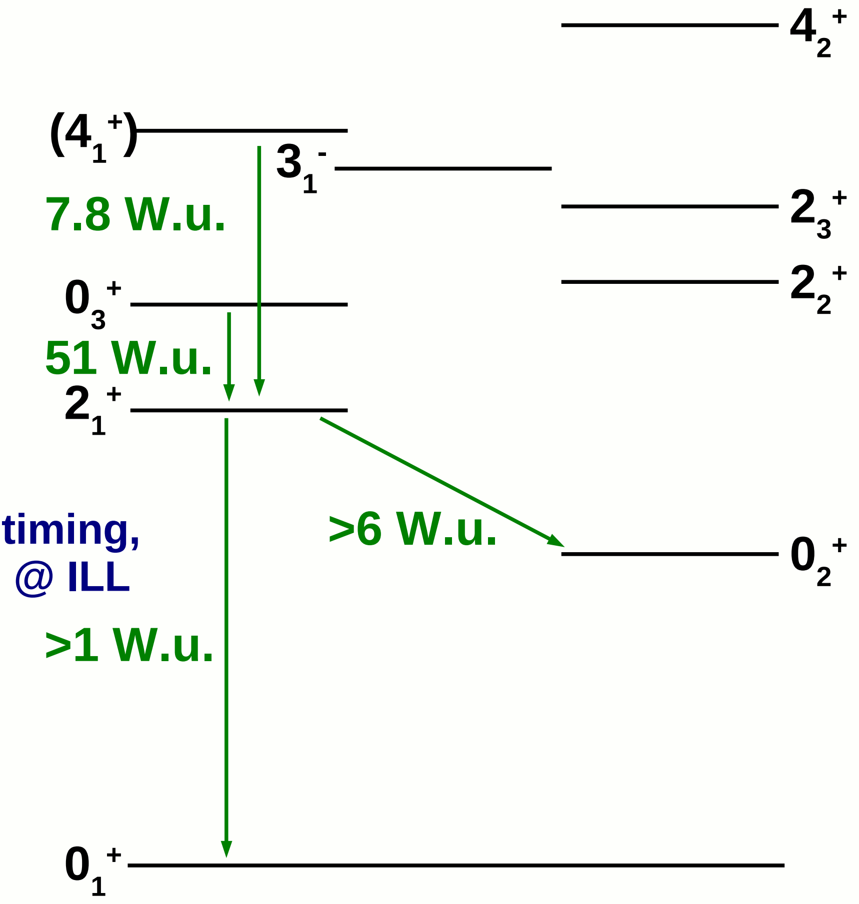


V. Werner et al., PRC 78, 031301 (2008)
E. Elhami et al., PRC 75, 011301 (2007)

In N>56: Does deformation develop from a coexisting structure ?
Is there a MS 2+ state below 2 MeV ?

^{98}Zr: Relevant Levels

Known absolute strengths:



From fast-timing,
Lohengrin @ ILL
$\tau < 11$ ps

^{98}Zr: Relevant Levels

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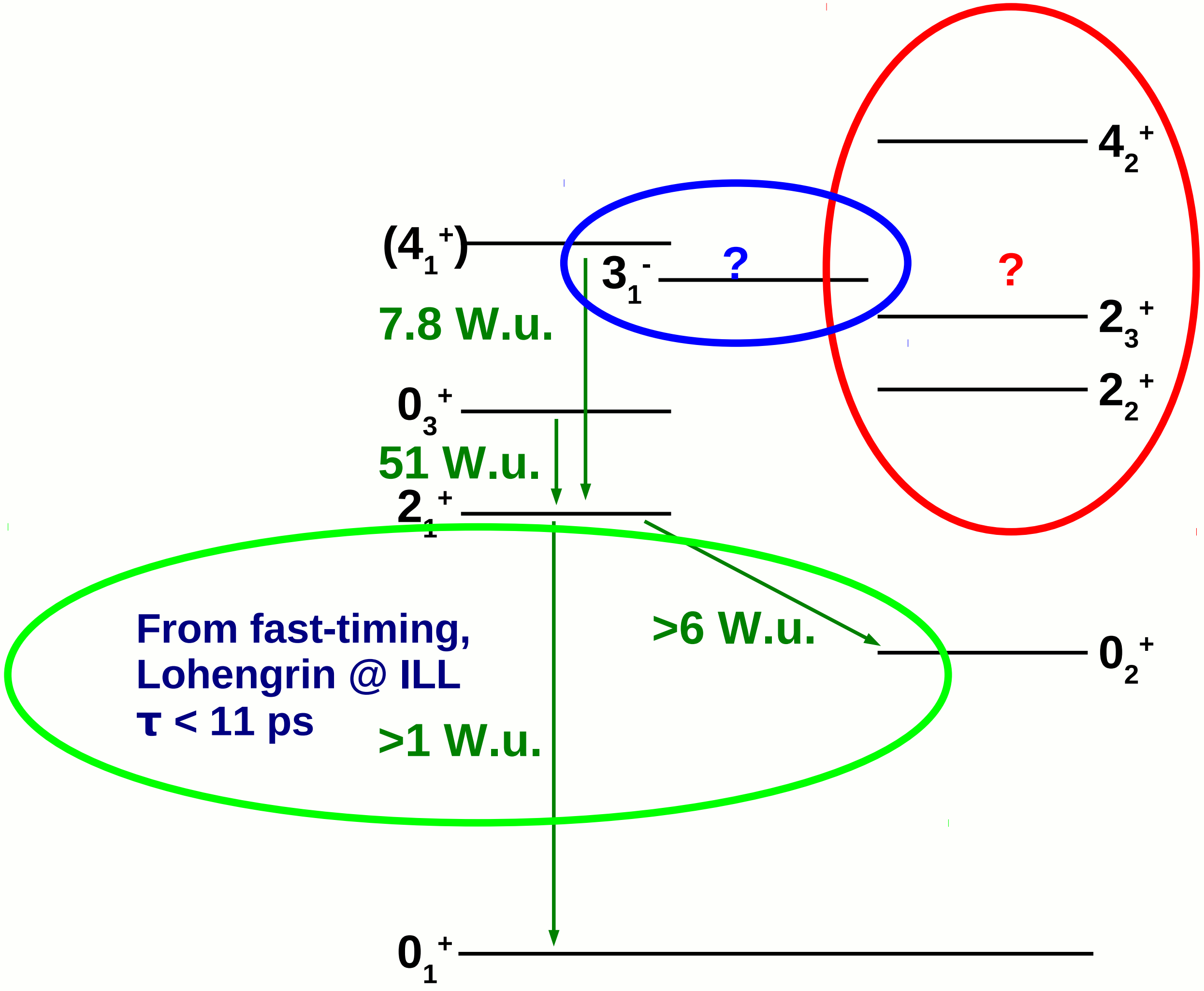

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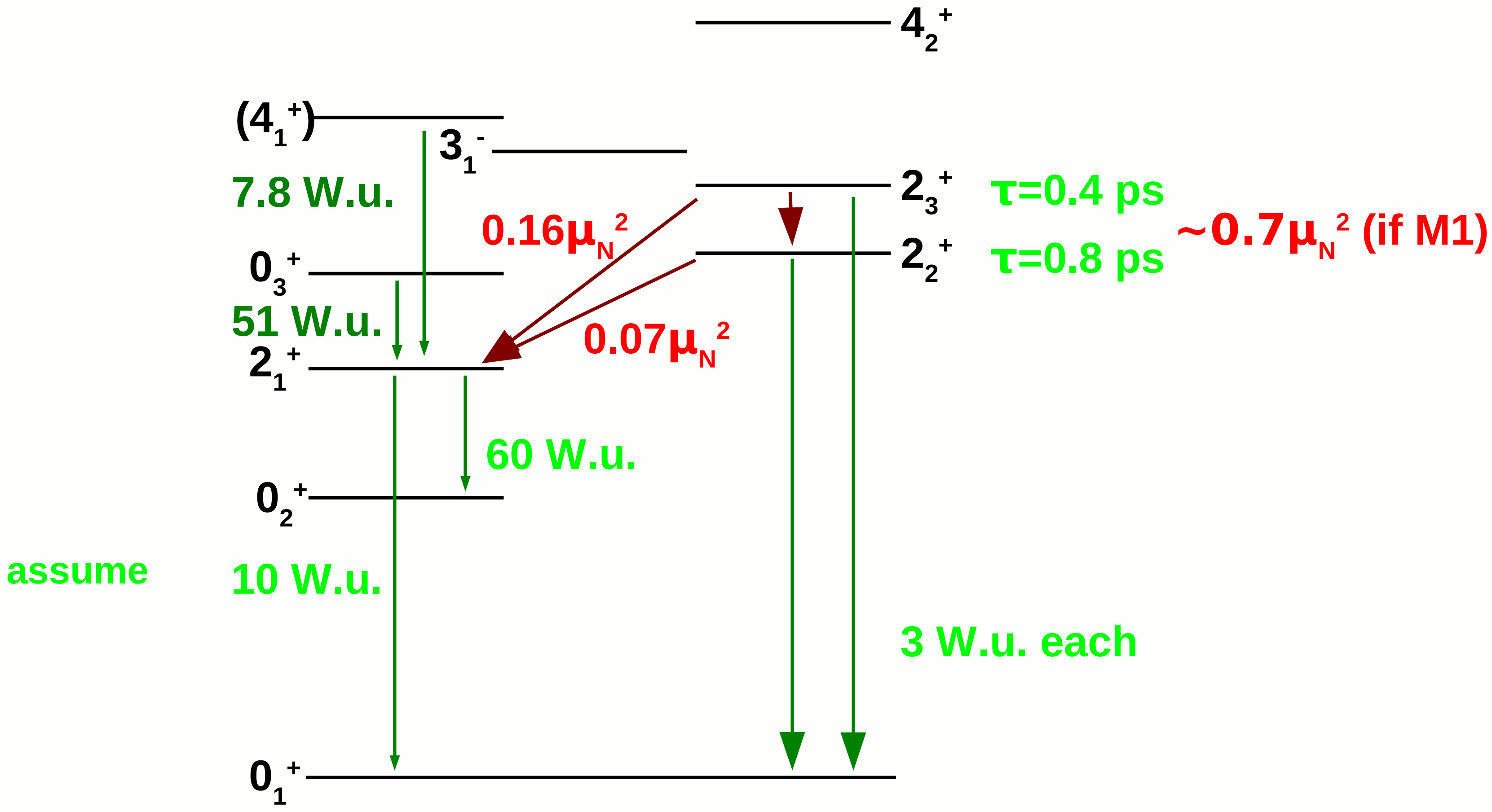
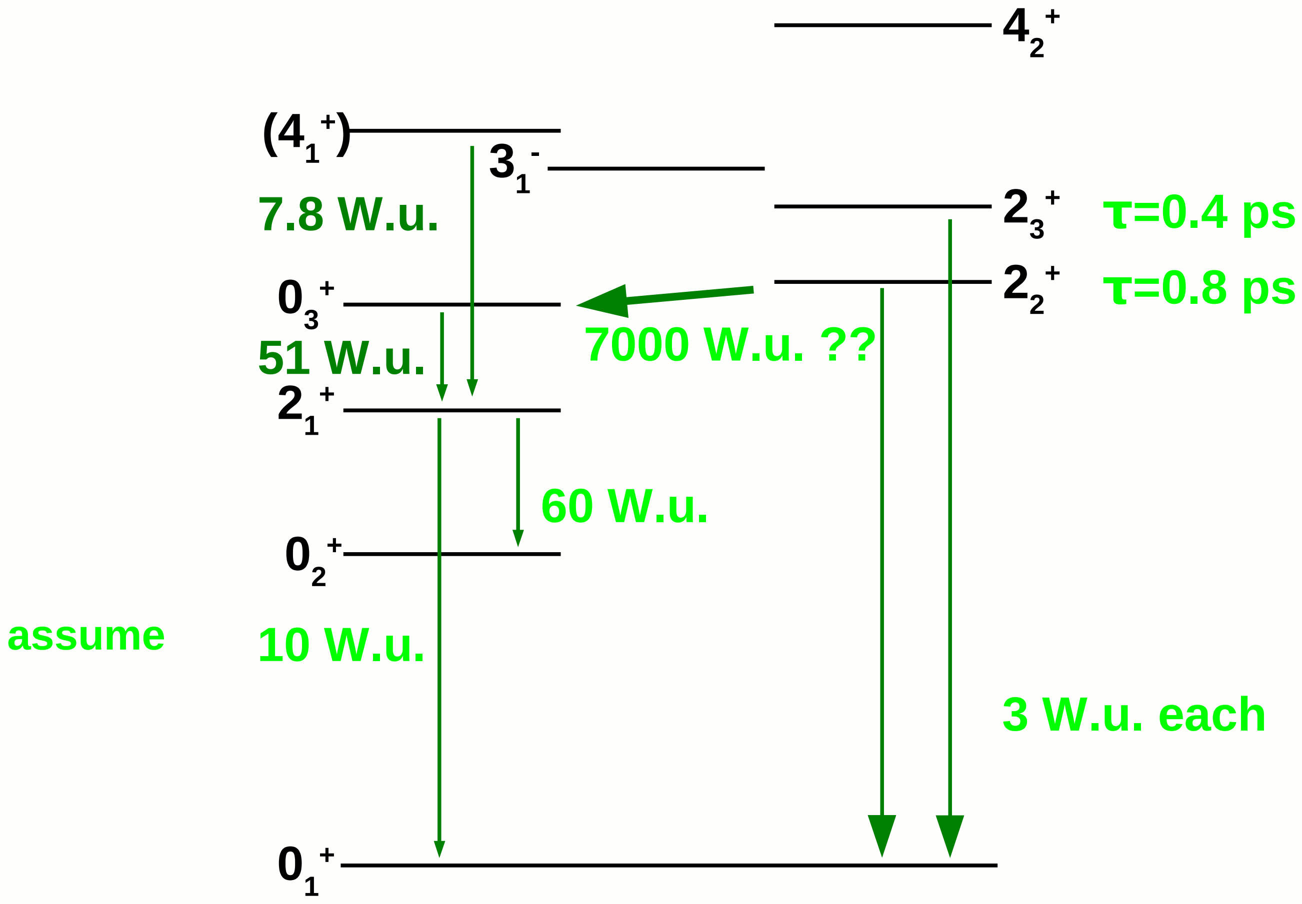
^{98}Zr: Relevant Levels

Assuming limits for the 2^+ states, branchings are known:



^{98}Zr: Relevant Levels

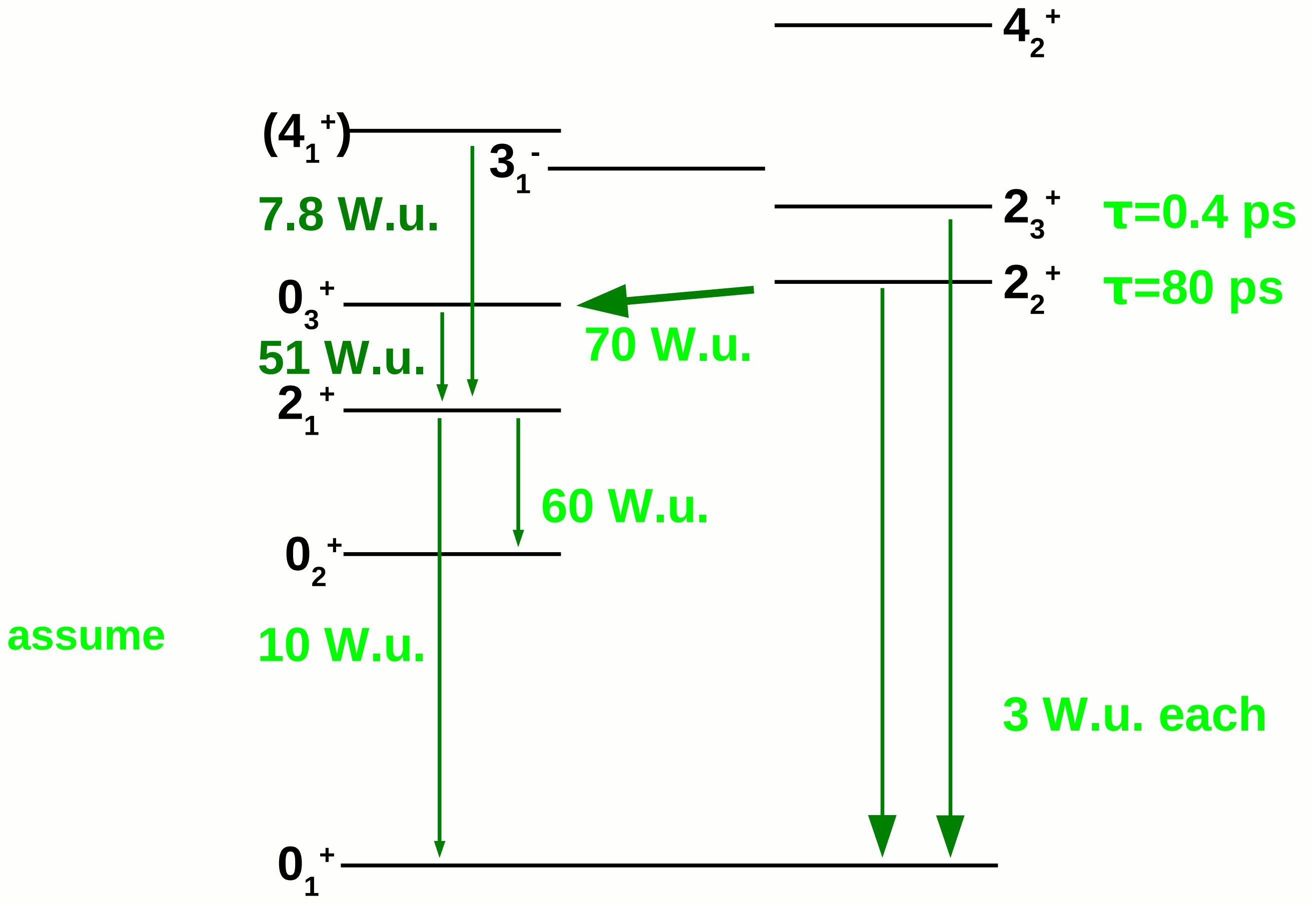
Branch of 2_2^+ states correct? Would give way too large 157 keV transition:



^{98}Zr: Relevant Levels

Different assumption could make it rotational state on top of 0_3^+

3^- is known to be very strong in ^{96}Zr, here?



Multistep Coulex

Only possible with GRETINA and CHICO2 for proper Doppler correction
=> reasonable peak-to-background !

Some rate estimates for above assumptions, 2400 pps ^{98}Zr @ 464 MeV, ^{196}Pt target *(relative measurement)*, CHICO2 forward shell for safe Coulex,

$2_1^+ \to 0_1^+$: 10 W.u. ~300 counts/day
$2_2^+ \to 0_1^+$: 3 W.u. ~ 30 counts/day
$2_3^+ \to 0_1^+$: 3 W.u. ~ 10 counts/day
$2_3^+ \to 2_1^+$: 0.16 μ_N^2 ~ 11 counts/day ***(indirect M1: if E2 it could be***
$4_1^+ \to 2_1^+$: 11 W.u. ~ 5 counts/day ***18000 W.u. otherwise...)***
$0_3^+ \to 2_1^+$: 51 W.u. ~ 40 counts/day

Assuming 50 W.u. Excitation strength for the 3^-:
$3_1^- \to 2_1^+$: ~ 16 counts/day

Primary goal: measure E2 strength of 2_1^+ few days
Test the nature of the $2_{2,3}^+$ states ~ 1 week for 50-100 counts

Shape coexistence around ^{100}Zr

- until today: $\tau(2^+_1)$ in ^{98}Zr is unknown (<11 ps)
- models (shell model, IBM) predict 1 – 5 ps

  (Bettermann et al., PHYSICAL REVIEW C 82, 044310 (2010))

- possible experiment:
  - ^{98}Zr beam provided by CARIBU (340mCi)
    - I=2400 pps
    - E=464 MeV (~88% of Coul. barrier)
    - ^{196}Pt (2mg/cm^2)
- Using CHICO2 (forward shell)
- Using GRETINA for measurement of γ rays

- estimated yield of target excitation (^{196}Pt):

  3500 cpd in $2^+_1 \rightarrow 0^+_1$ transition

- estimated lifetimes:
  - 2^+_2: 0.8ps
  - 2^+_3: 0.4ps

to normalize to GS transitions of ~3 W.u.

- include multipole mixing ratio of $2^+_3 \rightarrow 2^+_1$ transition of 0.2(1)

Transition	E_γ	Estimated B(EL)		w/o funny transitions	w/ funny Trans.
in ^{98}Zr	[keV]	[W.u.]		counts/day	
$2^+_1 \rightarrow 0^+_1$	1223	E2	(10)	311	197
$4^+_1 \rightarrow 2^+_1$	621	E2	11(5)	5.1	4.6
$0^+_3 \rightarrow 2^+_1$	213	E2	51(5)	41	25.8
$2^+_2 \rightarrow 0^+_1$	1591	E2	(3)	28	44
$2^+_2 \rightarrow 0^+_3$	155	E2	(7k)		0.9
$2^+_2 \rightarrow 2^+_1$	368	M1	(0.04)	8.8	13.7
$2^+_2 \rightarrow 0^+_2$	737	E2	(16)	3.2	5
$2^+_3 \rightarrow 0^+_1$	1744	E2	(3)	9.1	9.8
$2^+_3 \rightarrow 2^+_2$	153	E2	(18k)		0.3
$2^+_3 \rightarrow 2^+_1$	522	M1/ E2	(0.09)	11.4	12.3
$2^+_3 \rightarrow 0^+_2$	890	E2	(19)	3.0	3.2
$3^-_1 \rightarrow 2^+_1$	580	E3	(50)	16.0	15.7
^{196}Pt					
$2^+_1 \rightarrow 0^+_1$	356	E2	40.6(2)	3500	
$2^+_2 \rightarrow 2^+_1$	333	E2	57.7(8.8)	292	
$4^+_1 \rightarrow 2^+_1$	521	E2	60.0(9)	401	

^{98}Zr: Relevant Levels

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