Nuclear Moments of Isomeric States at REX-ISOLDE – Ideas and Necessities

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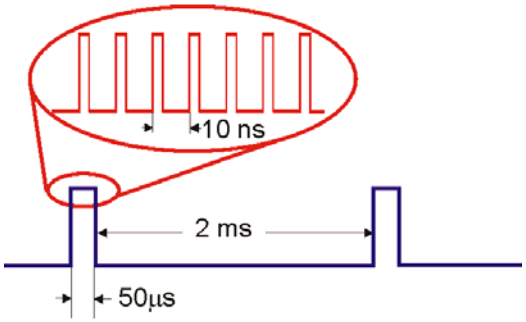
Nuclear Moments – Why and How?

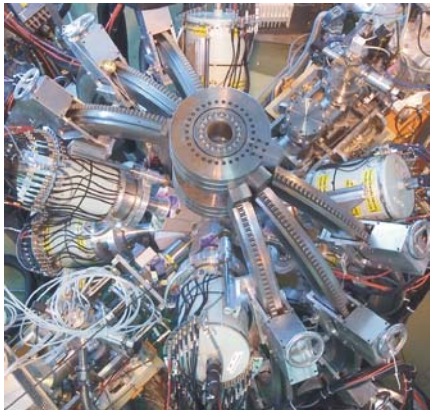
- Nuclear magnetic moments
  - clear signature of the proton/neutron character of the valence nucleons;
  - strong insight to the single-particle properties of the nuclear wave function;
  - revealing the interplay between the single-particle and collective properties of the nuclear state.
- How do we measure nuclear moments with RIBs???
  - projectile-fragmentation – orientation from the production mechanism **BUT-** limitation for $t_{1/2}$ > ~100 ns
  - ISOL beams
    - post-acceleration 3 – 5 MeV/u
    - production mechanism – Coulomb excitation, transfer reactions …?
    - "technical details" – beam timing characteristics, particle – gamma correlations, detectors timing response
- Possible candidate?
  - isomeric state in ^{68}Cu – member of the $\pi p_{3/2} \otimes \nu g9/2$ (3^-, 4^-, 5^-, 6^-) multiplet

Necessities

- Nuclear spin-oriented ensemble – ***a must!***
  - short-lived isomeric states – only reaction/production induced orientation is applicable;
    - nuclear transfer reactions?
    - Coulomb excitation??
- Time-structure of the beam
  - beam pulsing (loss of intensity) or
  - particle-γ correlation techniques – will it work and to what extend?

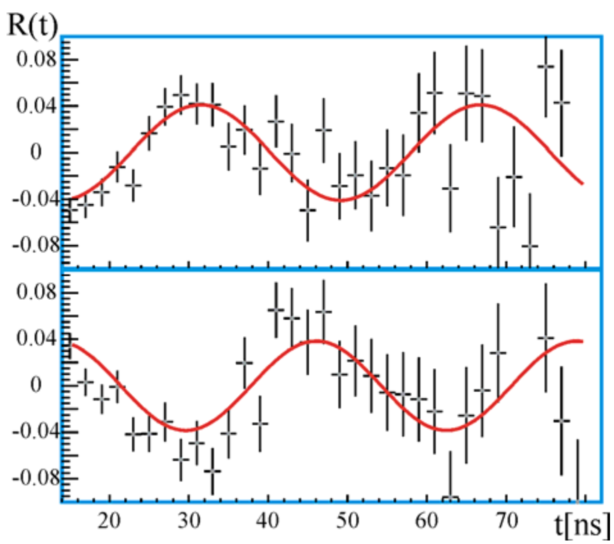


- "Flexible geometry" (positioning of the γ-ray detectors) specific for each case – standard MB
- Good time resolution of the γ-ray detectors – for the time-dependent methods



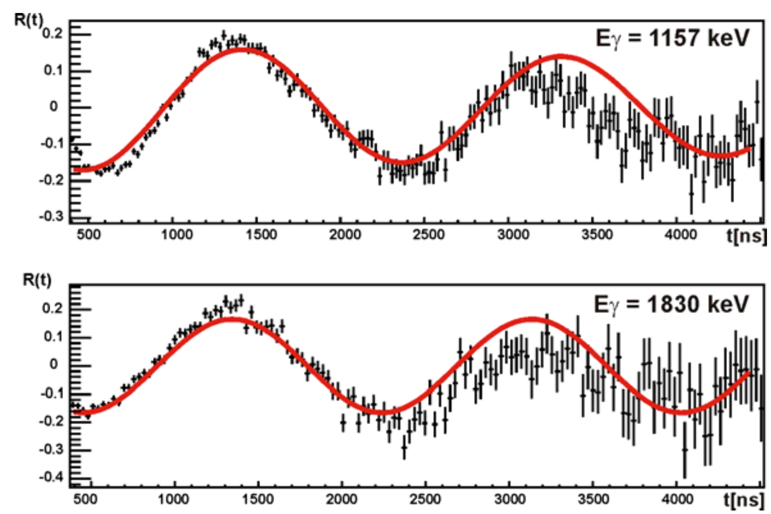
Nuclear orientation in transfer and pick-up reactions

$^{64}Ni(d,p)^{65m}Ni$ @ 3 MeV/u



Ampl. $_{R(t)}$ ~ 5%

$^{40}Ca(^{32}S,^{29}P)^{43m}Sc$ @ 3.8 MeV/u

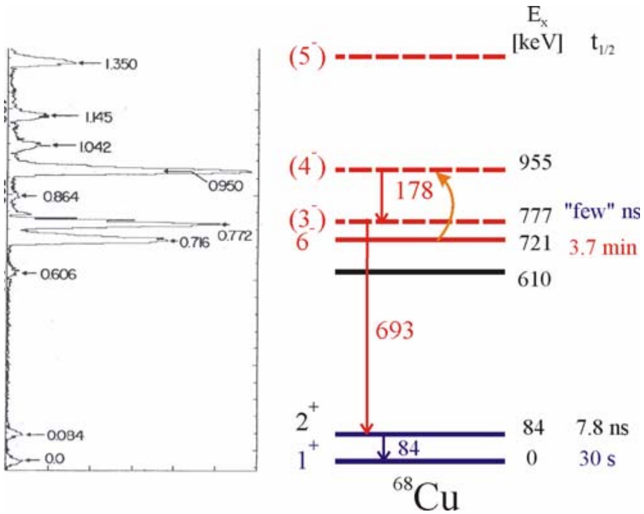


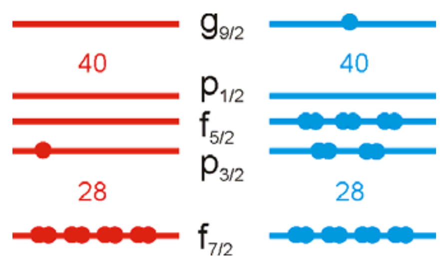
Ampl. $_{R(t)}$ ~ 17%

Significant "integral" alignment (without particle-γ correlations)

- Can we use it in inverse kinematics?
- Would the particle-γ correlations enhance it???
- Is it possible to use the particle-γ correlations instead of beam pulsing

^{68m}Cu – good "test" case?



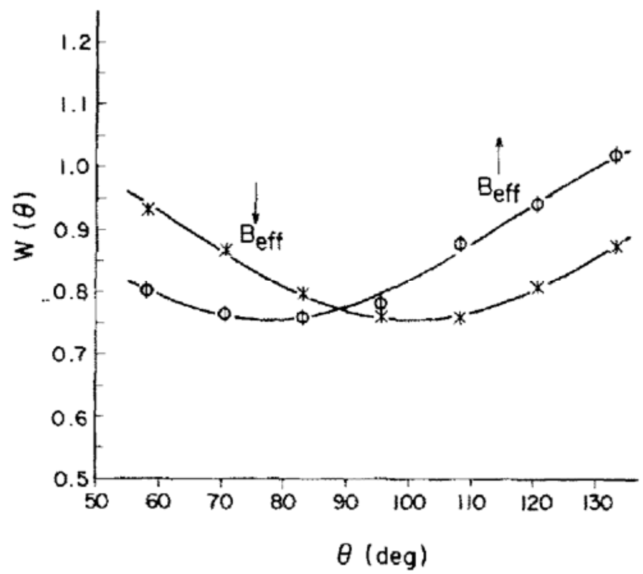


$\pi p_{3/2} \otimes \nu g_{9/2}$

$I^{\pi} = (3,4,5,6)^-$

I^{π}	g
6$^-$	+0.207
5$^-$	-0.008
4$^-$	-0.384
3$^-$	-1.135

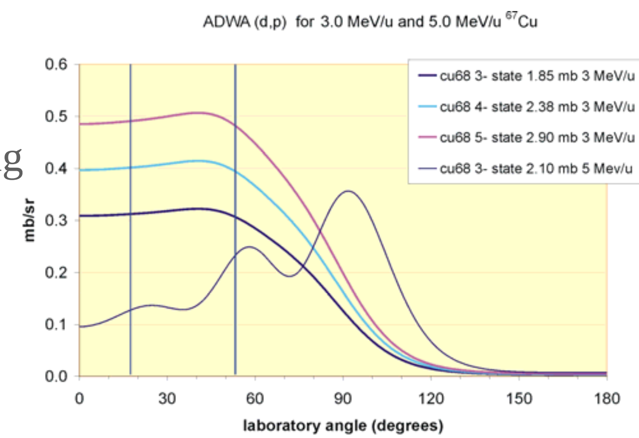
measured
L. Weissman *et al.*
PRC65 (02) 24315



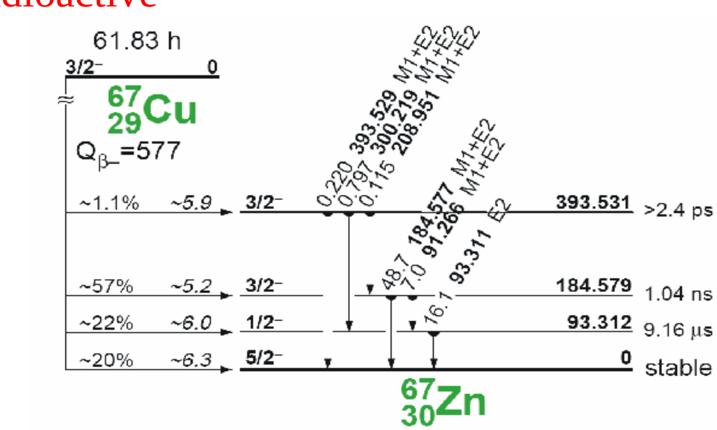
- g factor – clear distinction between different couplings
- Isomeric state of "few" ns, E_{γ} = 693 keV
- production – Coulomb excitation *vs.* transfer

HOW – Coulomb excitation or transfer?

• beam	^{68m}Cu	^{67}Cu
– intensity	- 10^6 pps	- 3 10^6 pps
• target	^{12}C plus backing	deuterated + backing
• particle – γ correlations	^{12}C	protons
• cross section	~ 4 mb	~ 2 mb (3^-, 4^-, 5^-)
• production	~1500 excitations/h → 3 γ's per det./h	~2000 isomers/h → 4 γ's per det./h
• orientation	~ 8 %	??? might be higher
	disadvantage →"real" radioactive beam - 1.5 γ per implanted ^{68}Cu ion 2/3 with E_γ > 1000 keV	advantage → "quasi" radioactive beam



W.N. Catford



Perspectives

- isomeric beams – open larger possibilities for the production of states of interest
- g-factor measurements with radioactive beams in inverse kinematics – possible but several points to be worked out (stable beams ^{63}Cu and ^{65}Cu experiment accepted at the Tandem of Orsay – to use part of TIARA for particle detection):
  - orientation in transfer reactions in inverse kinematics
  - particle-γ correlations
    - applicability and in what range?
    - possibility to avoid beam pulsing???
    - time resolution of the gamma detectors – quite important for time-dependent measurements
- magnetic moment observable – indispensable part of the "spectroscopy" information for the exotic nuclei

Collaboration

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