New Interpretation of the Low-lying Collective Nuclear Structure of ^{94}Zr

A. Chakraborty[1], E. E. Peters[1], B. P. Crider[1], C. Andreoiu[2], P. C. Bender[3], D. S. Cross[2], A. B. Garnsworthy[3], P. E. Garrett[4], G. Hackman[3], B. Hadinia[4], S. Ketelhut[3], Ajay Kumar[1], K. G. Leach[4], M. T. McEllistrem[1], J. Pore[2], F. M. Prados-Estévez[1], E. T. Rand[4], B. Singh[5], E. R. Tardiff[3], Z.-M. Wang[3], J. L. Wood[6], and S. W. Yates[1]

[1]*Departments of Chemistry and Physics & Astronomy, University of Kentucky, Lexington, KY 40506-0055, USA*
[2]*Department of Chemistry, Simon Fraser University, Burnaby, British Columbia V5A 1S6, Canada*
[3]*TRIUMF, University of British Columbia, 4004 Wesbrook Mall, Vancouver, British Columbia V6T 2A3, Canada*
[4]*Department of Physics, University of Guelph, Guelph, Ontario N1G 2W1, Canada*
[5]*Department of Physics and Astronomy, McMaster University, Hamilton, Ontario L8S 4L8, Canada*
[6]*School of Physics, Georgia Institute of Technology, Atlanta, GA 30332-0430, USA*

From new DSAM measurements with the (n,n'γ) reaction at the University of Kentucky and a study of the β⁻ decay of ^{94}Y (18.7 min) with the 8π array at TRIUMF, we have obtained a fuller characterization of the low-lying levels of ^{94}Zr. Using various scattering samples of natural isotopic composition, we have re-measured the lifetime of the 1671-keV 2_2^+ state and find it to be longer than previously reported [Elhami *et al.*, Phys. Rev. C **78**, 064303 (2008)]. In addition, the β⁻ decay studies have revealed new information, which leads to an interpretation of the low-lying structure of ^{94}Zr in terms of shape coexistence.

DSAM Measurement of the Lifetime of the 1671-keV 2_2^+ state in ^{94}Zr

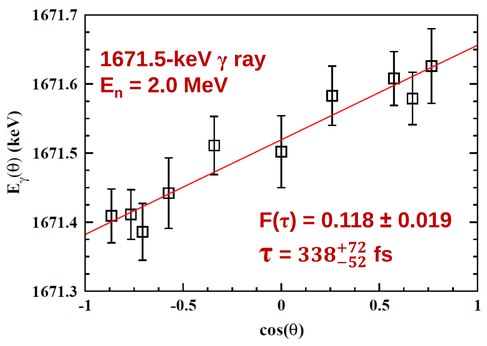
DSAM with the (n,n'γ) reaction*

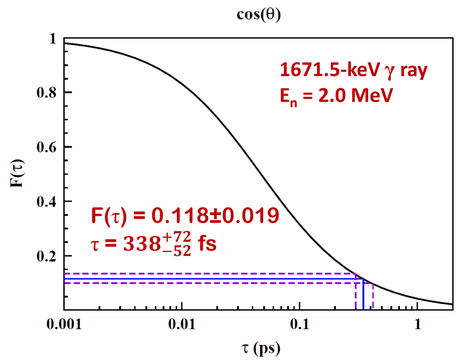
Monoenergetic Neutrons: ^{3}H(p,n)^{3}He Q = -1 MeV
Range of Lifetimes: 10^{-15} to 2 x 10^{-12} s (1 fs to 2 ps)
Energy of Doppler-shifted γ ray:

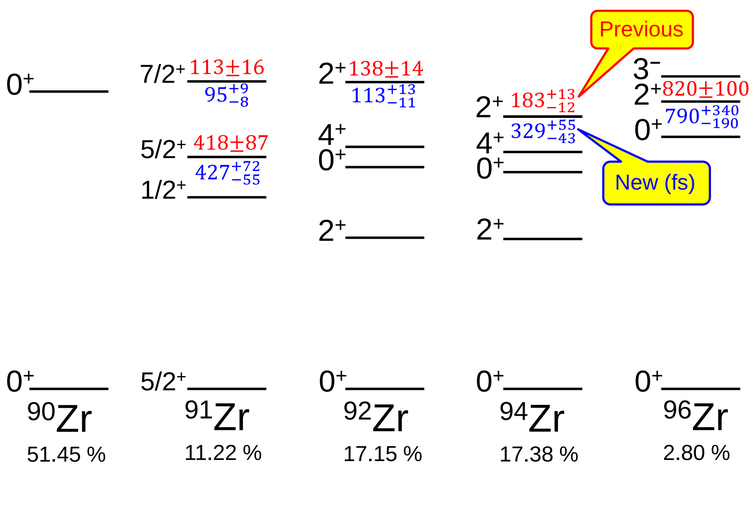
$$E_\gamma(\theta) = E_0[1 + F_{\exp}(\tau)\beta\cos\theta]$$

$$\beta = \frac{v_{cm}}{c} = 0.04635\left(\frac{A_n}{A_n + A_A}\right)\sqrt{\frac{E_n}{A_n}}$$

*T. Belgya, *et al.,* Nucl. Phys. **A500**, 77 (1989).
*T. Belgya, G. Molnár, and S. W. Yates, Nucl. Phys. **A607**, 43 (1996).

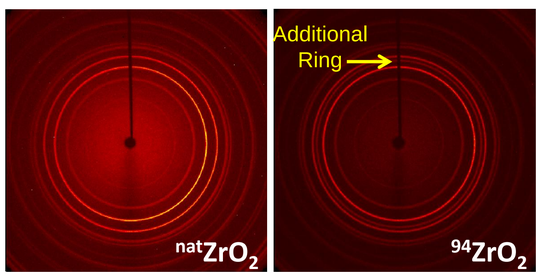


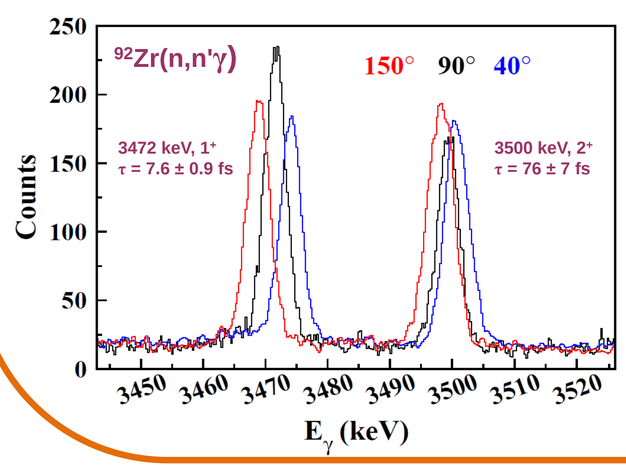


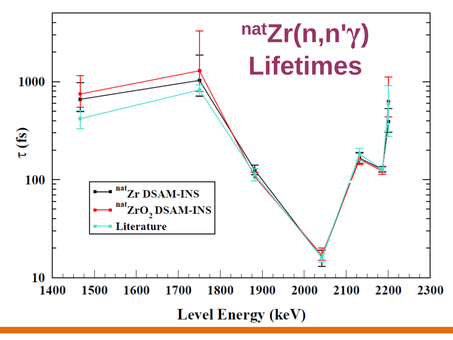


^{94}ZrO$_2$ Sample
98.57% enriched, leased from NIDC at ORNL
20 g in 2.6 cm x 3.9 cm container; ρ = 0.988 g/cm^3

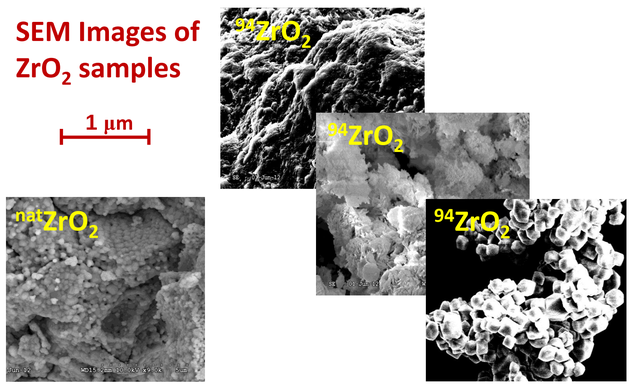
X-ray powder diffraction patterns of ^{nat}ZrO$_2$ used in the present measurements and ^{94}ZrO$_2$ used by Elhami et al.

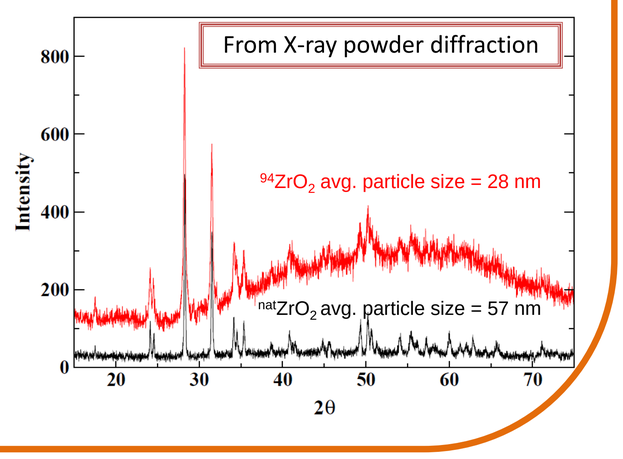






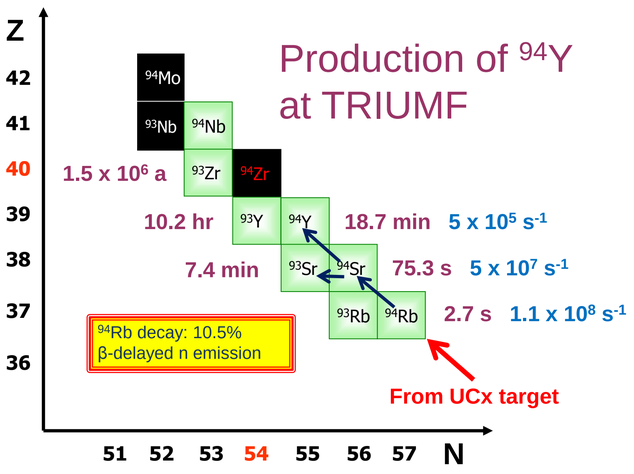
SEM Images of ZrO_2 samples

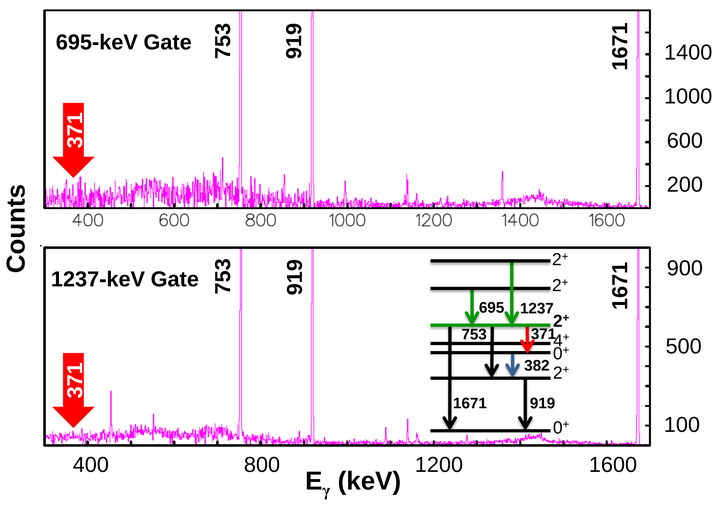


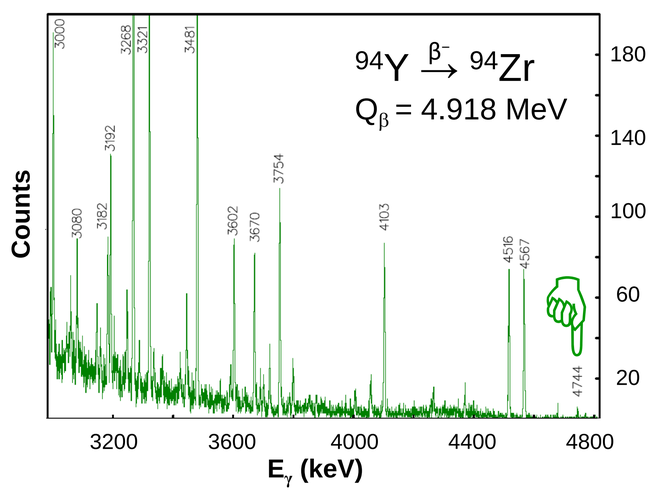


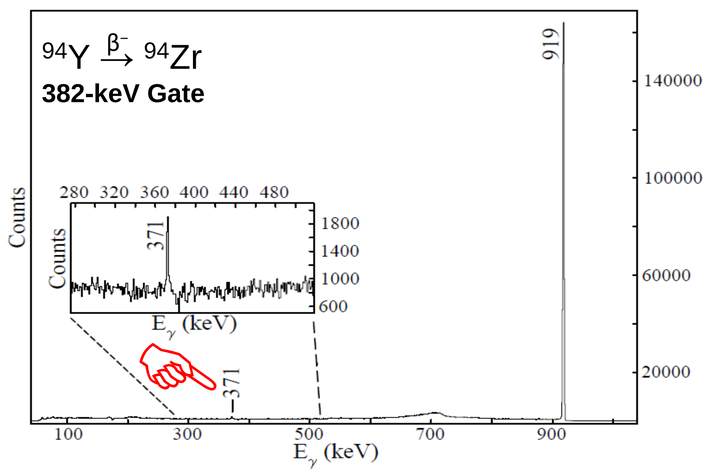
www.pa.uky.edu/accelerator

Shape Coexistence in ^{94}Zr from the β⁻ Decay of ^{94}Y



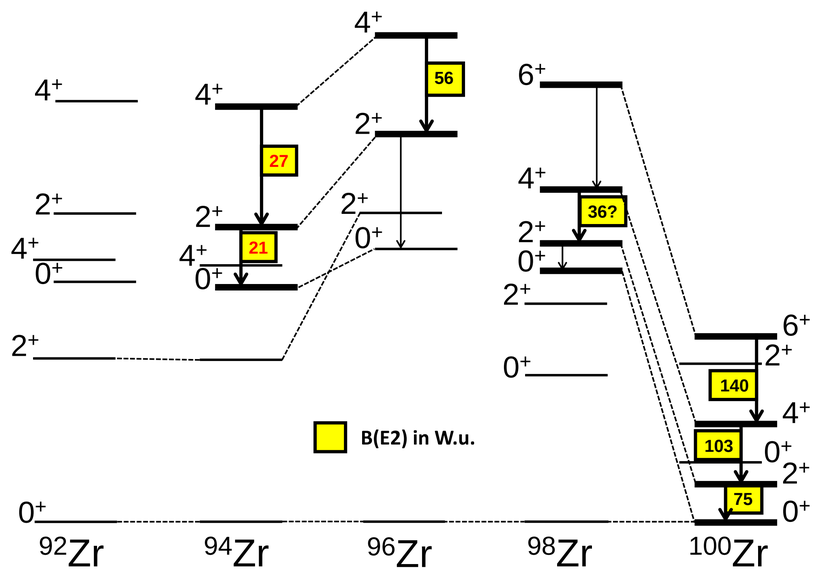






$$N_{12} = NI_{\gamma 1}B_{\gamma 2}\varepsilon_{\gamma 1}\varepsilon_{\gamma 2}\varepsilon_{12}\eta(\theta_{12})$$

$I_{\gamma 1}$= intensity of feeding γ ray
$B_{\gamma 2}$= branching fraction of draining γ ray
$\varepsilon_{\gamma 1},\varepsilon_{\gamma 2}$= singles photopeak efficiencies
ε_{12}= coincidence efficiency
$\eta(\theta_{12})$= angular correlation attenuation factor



This material is based upon work supported by the U. S. National Science Foundation under Grant No. PHY-0956310.