# TWO AND FOUR PROTON DECAYS IN $^{8}$C AND $^{12}$O GROUND STATES AND THEIR ISOBARIC ANALOGS

R. J. Charity[1], M. F. Jager[1], L. G. Sobotka[1], Z. Chajecki[2], D. Coupland[2], J. M. Elson[1], H. Iwasaki[2], M. Kilburn[2], M. Kurokawa[5], J. Lee[2], W. G. Lynch[2], J. Manfredi[1], S. T. Marley[3], M. McCleskey[4], H. Mohammad[1], R. G. Pizzone[4], B. T. Roeder[4], R. Shane[1], A. Sanetullaev[2], D. V. Shetty[3], E. Simmons[4], A. Spiridon[4], L. Trache[4], M. B. Tsang[2], J. Winkelbauer[2], A. H. Wuosmaa[3], M. Youngs[2]

[1] *Washington University, St. Louis, MO 60130, USA*

[2] *NSCL, Michigan State University, East Lansing MI 48824, USA*

[3] *Western Michigan University, Kalamazoo, MI 49008, USA*

[4] *Texas A&M University, College Station, Tx 77843*

[5] *RIKEN Nishina Center, Wako, Saitama 351-0198, Japan*

Two-proton decay of the proton-rich members of the $A$=8 and 12 quintets ($T$=2) have been studied. The $^{8}$C ground state and its isobaric analog state (IAS) in $^{8}$B were created in neutron and proton knockout reactions from a $^{9}$C beam at the National Superconducting Cyclotron Laboratory. The decay products were detected in the HiRA array and the parent nuclei were reconstructed using the invariant mass method. Using a $^{13}$O beam produced at the Texas A&M Cyclotron facility, the $^{12}$O ground state and its IAS in $^{12}$N were produced and the two-proton-decay products detected. Highlights of this work are:

- The ground state of $^{8}$C decays into an $\alpha$ particle and four protons. From the correlations between the decay products, we infer that decay was not five-body in nature, but proceeded as two sequential steps of two-proton decay passing through the $^{6}$Be intermediate state. The first two-proton step had an enhanced "diproton" component.

- The width of the $^{12}$O ground state was determined to be less than 72 keV, incompatible with previous measurements, but consistent with theoretical predictions.

- The IAS's of $^{8}$C in $^{8}$B and $^{12}$O in $^{12}$N were found to undergo two-proton decay to the IAS's in $^{6}$Li and $^{10}$B, respectively. These states represent a new class of two-proton emitters where single-proton decay is energetically allowed, but isospin forbidden, whereas two-proton decay conserves both quantities. This was the first observation of the IAS in $^{12}$N.

- For isospin symmetry, the masses of the quintets should follow a quadratic dependence on isospin projection given by the isobaric multiplet mass equation (IMME). Using our new values of the masses of the observed states, we find the $A$=8 quintet has deviations from the IMME where the $A$=12 quintet is consistent with it.

This work was supported by the U.S. Department of Energy, Division of Nuclear Physics under grants DE-FG02-87ER-40316, DE-FG02-93ER40773 and DE-SC004972 and the National Science Foundation under grants PHY-0606007 and PHY-9977707.