# Laser Trapped Radioactive $^{21}$Na

*, S. J. Freedman, B. K. Fujikawa, M. A. Rowe, N. Scielczo, P. A. Vetter*

Radioactive isotopes confined in neutral atom traps provide a localized, isotopically pure sample in which source scattering is eliminated. This offers the possibility to study weak interaction correlations such as the asymmetry in the β-decay of spin-polarized nuclei, and the electron-neutrino correlation. Traps also provide samples ideal for precision atomic spectroscopy of unstable atoms.

We have made a precise determination of the hyperfine splitting of the $3S_{1/2}$ ground state of $^{21}$Na.* This measurement, the first microwave transition observed in laser trapped radioactive atoms, took advantage of the long observation time and sensitive detection available with atoms nearly at rest in a trap. This technique can be useful in rare and short-lived alkalis for precise hyperfine spectroscopy on strings of isotopes.** We are currently measuring the hyperfine splitting of the excited $3P_{1/2}$ state using a similar technique. A precise (1 part in 10^5) measurement will allow extraction of the isotopic hyperfine anomaly, the dependence of the hyperfine splitting on the nuclear magnetization distribution in addition to the usual dependence on the nuclear magnetic moment.

The hyperfine splitting measurement starts with the collection of about 50,000 $^{21}$Na atoms in our magneto-optical trap. Next the trap's re-pump laser is turned off. The atoms are driven into the lower ground state level (F=1). The trapping lasers and quadrupole magnetic field are then turned off, leaving only a small bias magnetic field. The cold atoms receive a 1 ms pulse of microwaves to measure the ground state splitting, or a pulse of D1 laser light to measure the excited state splitting. A probe laser is turned on and the atomic fluorescence is measured to indicate a transition to the upper level (F=2) arising from the microwave or D1 laser pulse. Repeating these steps with different microwave (laser) frequencies maps the resonance. A zero field splitting between the $3S_{1/2}$ (F=1) and $3S_{1/2}$ (F=2) levels of $^{21}$Na was determined to be 1906471880+/-200Hz.

We have also constructed a new microsphere plate detector near the magneto-optic trap to measure the recoiling $^{21}$Ne ions after the β decay. Using a time-of-flight technique, we can infer the momentum of the undetected neutrinos to measure the β–ν correlation. Monte-Carlo simulations of time-of-flight spectra (Fig. 1) indicate that we can statistically achieve a 10% measurement of the β–ν correlation parameter, which would limit scalar current contributions to (V-A) electroweak currents. We expect that the detection of coincident β–ion pairs will reduce our background β count rate, which limited our ability to perform other correlation experiments. During 1999, we intend to install and test the new microsphere plate.

*Footnotes and References*

* M.A. Rowe, *et al.*, Phys. Rev. A **59, (1999).**

**H. T. Duong et. al., CERN-PPE/92-141, July 30 (1992)

‡O. Naviliat-Cuncic et. al. J. Phys. G 17,919 (1991)

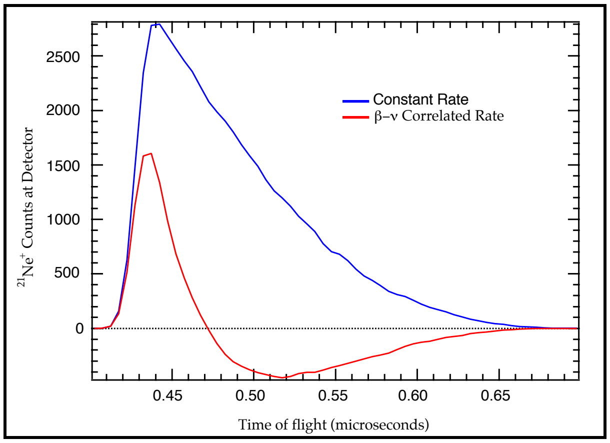

Fig. 1. Monte Carlo simulation of time-of-flight spectrum for coincident β–ion events at our microsphere detector. The differential rate (red) is caused by the β–ν momentum correlation.