Beta Neutrino Correlation in Laser Trapped ^{21}Na

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We have made a preliminary measurement of the beta-neutrino correlation parameter **a** in ^{21}Na using a laser trapping technique. The beta decay rate for an unpolarized beta source can be written $\Gamma \propto 1+\mathbf{a}\left(\vec{p}_e \bullet \vec{p}_\nu / E_e E_\nu\right)$, where $\vec{p}_e$ and $\vec{p}_\nu$ are the beta and neutrino momenta. The $\beta-\nu$ correlation **a** can be calculated in the Electroweak Standard Model to be 0.558 for the decay ^{21}Na -> ^{21}Ne+β^++ν. A precise measurement of **a** can limit the existence of scalar or tensor currents in extensions to the Standard Model, caused for instance by massive leptoquarks.

Although the neutrino momentum cannot be directly measured, it can be inferred by measuring the momentum of the recoil nucleus ^{21}Ne. This is measured by detecting the time of flight of the ^{21}Ne to a detector after a beta is detected (nearly instantaneously after the decay). The time of flight depends on the initial ^{21}Ne momentum and an accelerating electric field provided by a series of plates and rings. We fit the time of flight spectrum to a sum of two independent terms, one of which is proportional to **a**. We generate these template curves by Monte-Carlo simulation of the flight path of ^{21}Ne ions in the numerically calculated electric field for our geometry.

We produce ^{21}Na ($T_{1/2}$ = 22.5 s) on-line at the 88" Cyclotron by bombarding a heated magnesium oxide target with protons. A hot, neutral atomic beam of ^{21}Na emerges from the target. Passive and active laser collimation increases the forward flux of the ^{21}Na beam towards our laser trap. The ^{21}Na is slowed and trapped with a combination of laser and magnetic fields and brought nearly to rest (RMS velocity is < 3 cm/s) in a small (< 1 mm diameter) trap of up to 50,000 atoms, located between our beta and recoil ion detectors. As the ^{21}Na decays, we detect coincident beta-ion events defined by a 3 µs timing window after a beta hit trigger. Singles rates in both detectors, beta energy, and time of flight are recorded. The time-of-flight is digitized with a resolution of ~500 ps and a total calibration uncertainty of < 1 ns.

During 1999, we completed installation of a microsphere plate (MSP) detector in our laser trapping apparatus. The MSP can detect the recoiling ^{21}Ne ions with nearly 100% efficiency. Detecting coincident events in the MSP and a plastic scintillator beta detector greatly improved signal to background resolution over our previous single detector geometry. Data recorded during ~15 hours of acquisition time and a roughly equal amount of background (no trapped atoms present) is shown in Fig. 1. From fits to this data, we extract **a**=0.62(10) (statistical uncertainty), consistent with calculations of **a**=0.558. During 2000, we will acquire more data, with a goal of reducing the statistical uncertainty of **a**. We are implementing several improvements in our setup to increase our data rate and thereby reduce our acquisition time. We also intend to measure the branching ratios of the various possible charge states of the ^{21}Ne after the decay, three of which are visible in Fig. 1.

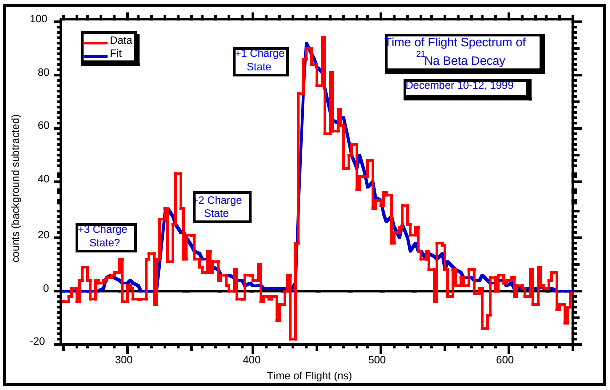

Fig. 1. Approximately 15 hours of data acquired with trapped ^{21}Na.

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