Upgrades and status of the ^{37}K β-asymmetry experiment

R. S. Behling, B. Fenker, M. Mehlman, D. Melconian, and P. D. Shidling

The TRINAT collaboration performed a successful experiment to measure the beta-asymmetry parameter in ^{37}K in December of 2012. While progress in the analysis of this data is described in a separate report, we have also upgraded the apparatus in preparation for a run in May-June of 2014 with the goal of achieving an overall uncertainty of less than 0.5% in the beta-asymmetry. These upgrades include the installation of a forced-air cooling system for the silicon-strip detectors, stabilized LED gain monitoring of the photomultiplier tubes, and the installation and development of a new, larger set of micro-channel plates (MCPs) including a delay-line anode for position information.

The primary detection system in our apparatus is a pair of beta-telescopes placed along the nuclear polarization axis. We measure the beta-asymmetry by comparing the count rate in the detector parallel to the nuclear spin with that of the detector anti-parallel to the nuclear spin. Each beta-telescope consists of a thin silicon-strip detector backed by a plastic scintillator. The scintillator measures the full energy of the positron while the silicon detector helps to veto the gamma background and measure the positron's position. During the 2012 run, each of our double sided silicon-strip detectors (DSSSD) showed a leakage current about eight times the normal value. This large leakage current can decrease the pulse height and therefore increase the energy threshold of the detector. We attribute the leakage current to inductive heating of the detector and its surroundings by eddy currents induced in the vacuum chamber by the oscillating magnetic field that is necessary to produce the alternating-current MOT (AC-MOT). To keep the DSSSD nearer to room temperature, we have installed a gas system to cool the detectors by forced convection. Tests of this system demonstrate that it successfully cools the detectors enough that they maintain an acceptable leakage current.

The light output from the plastic scintillators described above are read out by a photomultiplier tube (PMT). It is well known that the gain of PMTs drift over time due to variations in temperature and count rate. In order to monitor these drifts over the roughly three week duration of our experiment, we have built a stable three-tiered gain-monitoring system. The gain of the PMTs are monitored by periodically injecting into them an LED pulse of constant brightness. Assuming a perfectly constant LED brightness, any variations in output charge are then attributable to drifts in the gain of the PMT. Since the brightness of standard LEDs are known to vary over time by a few percent, we use an optical fiber to split a constant fraction of the light output to a photodiode (PD) which gives an independent reading of the brightness. The PD's output signal is then used to drive an active gain-stabilization feedback loop designed by Y. Holler [1]. As a final precaution, we house the PD in a temperature stabilized box in order to minimize gain drifts in this detector. The temperature and LED stabilization units have been tested to work satisfactorily and the PMT's gain monitoring will be installed before the upcoming May-June run.

In addition to the detector systems described above, we use two sets of micro-channel plate (MCP) detectors to provide additional information about the decays. One of these detectors collects atomic shake-off electrons (SOEs) produced immediately following the positron-decay as a result of the sudden change in nuclear charge. The SOEs are focused onto the MCP by a constant electric field. The observation of one or more SOEs is critical for tagging events that have decayed from within the trap where the atoms are highly polarized. In 2012, we observed rate fluctuations in phase with the oscillating (1 kHz) magnetic field of the AC-MOT, implying that some SOEs were being deflected beyond the edge of the 20 mm radius MCP.

Over the past year, we have replaced this MCP with a larger (40 mm radius) one and added a delay-line anode to provide position sensitivity. The larger MCP will allow us to collect more shake-off electrons and increase our rate of positron-electron coincidences that we use for our asymmetry measurement. The position sensitivity will be useful in two ways. First, measuring the position distribution of the SOEs as a function of magnetic field strength provides a unique opportunity to measure the energy distribution of SOEs from 5-30 eV (the lowest energy data currently available in the literature is 150 eV) [2]. Although this is not our main experimental program, a dedicated measurement has been approved by TRIUMF. Secondly, the newly added position sensitivity will provide redundant information about the trap's position and size. Our standard technique is to periodically photoionize a small fraction of the trapped atom and sweep the positive ion to one set of MCPs and the shake-off electron to the set of MCPs described above. Previously the transverse position was only measured by the MCP stack detecting the photoion. In the current setup, the photoelectron position will also be recorded and used to redundantly measure the trap position. The larger MCP and delay-line anode have been commissioned in an offline test chamber and are ready for use in the upcoming run.

In addition to the upgrades described here, our collaborators at TRIUMF have made significant improvements to the trapping, polarizing, and vacuum systems. With these improvements in place, we are schedule to take data at TRIUMF from May 22-25 and June 6-13. During this time we will collect data for a less than 0.5% measurement of the beta-asymmetry parameter.

[1] Y. Holler, J. Koch, and A. Naini, Nucl. Instrum. Methods **204**, 485 (1983).
[2] J. Behr, "*Low-energy atomic electrons emitted in positron decay*," TRIUMF EEC Submission, 2014