Update on the TRIUMF Neutral Atom Trap (TRINAT) experiment

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The TRINAT collaboration continues to utilize neutral atom trapping and optical pumping techniques on short-lived β-decaying isotopes to probe the electroweak sector of the standard model.

Our analysis of the Fierz interference parameter [1] is ongoing. Our GEANT4 Monte Carlo for analysis is fully developed, however the computational time needed is exorbitant and cannot be used to fully analyze the data directly. We have therefore developed a relatively simple Monte Carlo with minimal overhead that is significantly faster (hours versus weeks). To minimize the bias this less-detailed simulation necessarily introduces, we have generated four separate response functions as a function of β energy in GEANT4: one for each of the upper and lower telescopes, both for each polarization state separately. We are about to benchmark our 'simple' MC to the full GEANT4 simulation and confirm that small variations of new physics around the best fit of the data using the standard model (*i.e.* $-0.25 \leq C_S \leq 0.25$) are the same for both MCs. Once this is confirmed, the final analysis should proceed quickly.

We also continue to analyze data taken from the decay of ^{92}Rb, which dominates the neutrino energy spectrum from reactors in the 5–7 MeV range where there is currently an unexplained excess of events [2]. By measuring the momenta of the charged recoil and β, and knowing the decay occurred from rest at the trap centre, we are able to directly reconstruct β-ν correlation parameter. Although $a_{\beta\nu}$ is naïvely expected to be ≈1, two separate approaches of analyzing of our data indicate $a_{\beta\nu} = 0.4(1)$ [3]. This result constains the difficult-to-calculate matrix elemnts of ^{92}Rb's first-forbidden $0^- \rightarrow 0^+$ ground-state to ground-state decay. This analysis did not utilize the information of the position-sensitive Si-strip β detectors; along with a higher-resolution spatial calibration of our MCP recoil-detector, our momentum analysis will have greater resolution. In parallel with these improvements, we are developing GEANT4 simulations of this decay so that we can reconstruct the Q value of the decay and better isolate the ground-state transition.

Looking forward, our next beamtime at TRIUMF is likely to be a search for time-reversal violation (TRV) in the radiative β decay of ^{45}K. When parity violation was discovered in the late 1950's in beta and muon decay, people immediately proposed experiments testing time-reversal symmetry, hoping its violation might also be large. Any scalar triple product of momenta $\vec{p}_1 \cdot \vec{p}_2 \times \vec{p}_3$ flips sign with the sign of time: if its value does not average to zero, that indicates a violation of time-reversal symmetry. However, this scalar trivially vanishes from momentum conservation if there are only three momenta in the final state. To nontrivially test time-reversal symmetry without involving spin, we must look for a correlation of three momenta from a four-momentum final state. Our sensitivity to TRV is through a unique observable using our trap: the triple-vector correlation $\vec{p}_\beta \cdot \vec{p}_\nu \times \vec{p}_\gamma$, where we deduce $\vec{p}_\nu$ from the recoild momentum. The geometry of the proposed system is shown in Fig. 1, as well as preliminary GEANT4 simulations of our sensitivity to c_5, the parameter that is non-zero if TRV exists [4]. Since this observable does not involve spin, it is actually more directly sensitive to certain sources of TRV than electric dipole moments. This 3-momentum correlation has never been measured in the first generation of particles, so could still be large.

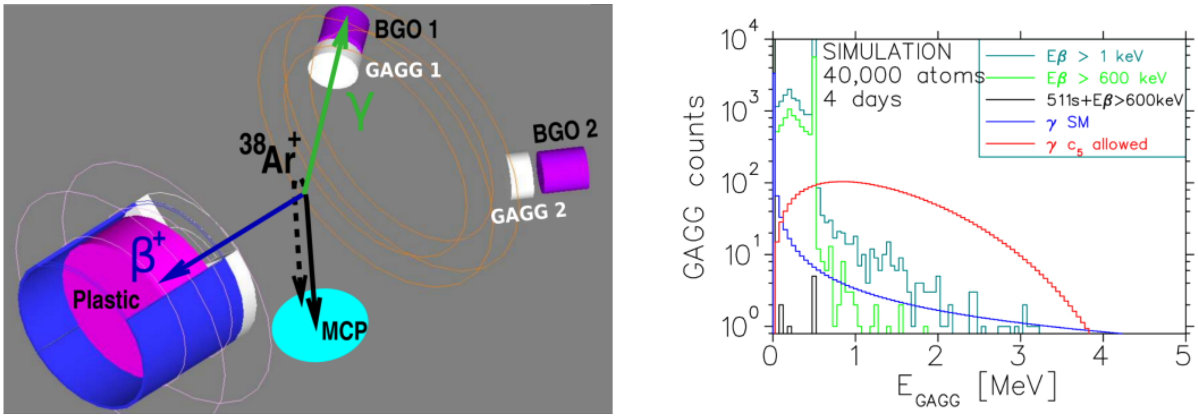

Fig. 1. The TRV experiment with TRINAT. Left: geometry of the detectors used to observe the triple-correlation. Right: GEANT4 simulation of the signal in the BG0 detector showing the sensitivity of the experiment.

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[2] D.A. Dwyer and T.J. Langford, Phys. Rev. Lett. **114**, 012502 (2015).

[3] J.C. McNeil, M.Sc. Thesis, University of British Columbia, 2019.

[4] S. Garnder and D. He, Phys. Rev. D **87**, 116012 (2013).