Time Reversal Invariance Violation in Polarized Neutron Beta Decay

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Evidence for CP violation and it's implied consequence: T violation has been established in the neutral kaon system and recently observed in B meson decays. Although there have been many searches for T violation in other systems, it has yet to be observed. The goal of the emiT experiment is to search for possible T violation in the beta decay of free polarized neutrons. This experiment is designed to detect a correlation of the form

$$D\hat{\sigma}_n \cdot \frac{\tilde{p}_e \times \tilde{p}_\nu}{E_e E_\nu}$$

which is odd under time reversal. A non-zero triple correlation coefficient, D, would imply T violation [2]. Several measurements of the D coefficient were made and the current world average, $D = -(0.6 \pm 1.0) \times 10^{-3}$, is consistent with zero. The first run of the emiT experiment was conducted at the National Institute of Standards and Technology (NIST) Center for Neutron Research (CNR). The experimental apparatus, shown in Fig. 1, utilizes an octagonal array of detectors to observe, in coincidence, electrons and recoil protons from neutron beta decay. The neutrons in the cold (T=40 Kelvin) beam are polarized to more than 93% with a supermirror polarizer. Electrons are detected with four 50-cm long plastic scintillators. The recoil protons, whose maximum energy is less than 750 eV, are accelerated by a 36 kV potential onto thin window charged particle detectors. The characteristic delay time between the decay proton and electron is used to distinguish signal from background. The proton drift time is greater than $0.5\,\mu$s and most backgrounds are prompt. Anticipated sources of systematic uncertainty were reduced in the detector design and measurements were made to assess the effect of certain crucial factors. The high neutron polarization and the high acceptance of the detector give this experiment a significant improvement in sensitivity over previous experiments. The first emiT run resulted in a value of $D = -(0.6 \pm 1.2_{stat} \pm 0.5_{syst}) \times 10^{-3}$ which is consistent with zero. This result has been published in Phys. Rev. C [1] and it represents a small improvement over the current world average.

Since the first emiT run ended in 1998, the emiT detector has undergone a major upgrade. The PIN diode proton detectors have been replaced by a thin window silicon surface barrier detector. These new detectors will improve proton detection efficiency and the uniformity of the detector which will allow many systematic effects to be reduced. Improved cooling, data acquisition, and on-line diagnostics have also been added. The second run begin in the Fall of 2002 at the NIST CNR and is currently underway. With this upgraded detector, we expect to overcome limitations experienced in the first and to improve the sensitivity to D to the 3×10^{-4} or less.

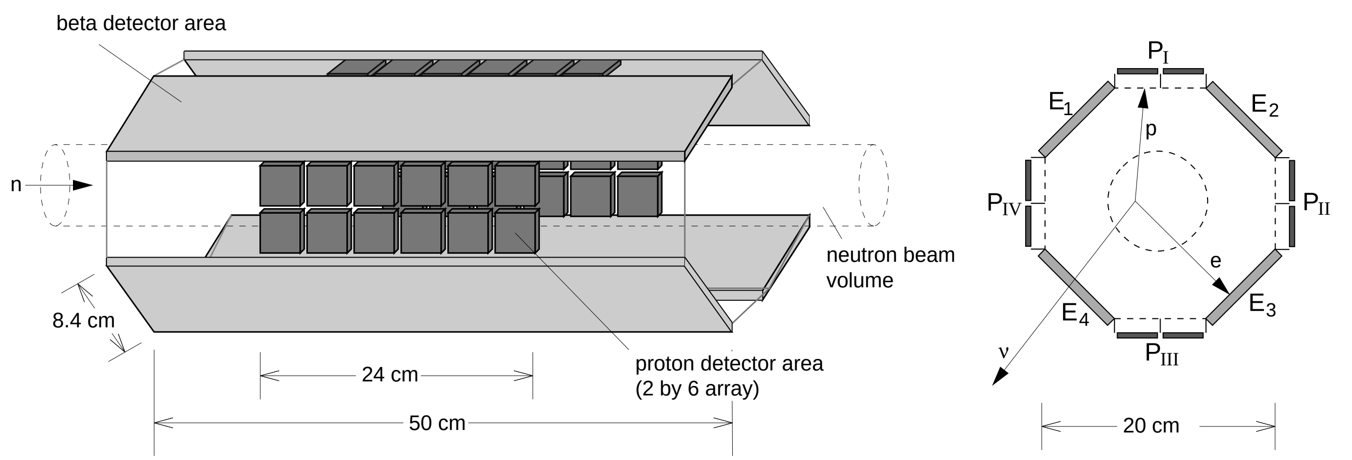

FIG. 1: Artist's conception of the emiT detector showing an octagonal array of four pairs of proton and electron detectors.

[1] L.J. Lising, *et al.*, Phys. Rev. **C 60**, 055501 (2000).

[2] Above final state interactions (FSI): $D_{FSI} = -5.7 \times 10^{-5}$.