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Enhancing Measurement Precision in PVES Experiments: The Impact of Bayesian Analysis on the Results of the Qweak and MOLLER Experiments

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Parity Violating Electron Scattering (PVES) experiments are a powerful tool for exploring physics beyond the Standard Model of particle physics. These experiments, which conduct highly accurate measurements of the parity-violating asymmetry across various kinematic conditions and targets, significantly contribute to advancements in particle, nuclear, and hadronic physics. Achieving precise measurements necessitates both experimental and theoretical corrections to the measured asymmetries.

Experimental corrections are required for background processes, characterized by fractional dilution factors and inherent background asymmetries. The implementation of auxiliary detectors to differentiate the main signal from background signals can enhance the signal-to-background ratio. However, certain uncontrollable factors during measurements, such as deviations in beam direction or spin alignment discrepancies caused by source imperfections, accelerator flaws, external magnetic fields, or subsystem misalignments, require post-measurement corrections to address these deviations.

This presentation will compare the Bayesian analysis with the frequentist method commonly used in PVES experiments, focusing on its application in improving the extraction of asymmetry components in both the Qweak and MOLLER experiments. The proposed Bayesian models are designed to infer background asymmetries based on observed quantities, thus enabling more accurate result corrections. A comparison of the fitted values from Bayesian analysis with the measured and precise simulation values shows that the Bayesian-fitted values more closely align with the exact simulation values than with the raw measured data. This alignment highlights the effectiveness of Bayesian analysis in compensating for measurement imperfections in PVES experiments.

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