

XVth Quark Confinement and the Hadron Spectrum



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Can we do beyond Wilks theorem for significance calculation? Estimating p-values with importance sampling

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Particle physics experiments often rely on statistical hypothesis testing to determine statements of discovery, evidence, or exclusion, typically assessed through p-values, “number of sigmas.” However, in many cases, the significance is evaluated using asymptotic formulae based on Wilk’s Theorem, without guarantees that its conditions are fulfilled. Alternatively, p-values can be assessed using simulations, “toy Monte Carlo” but extending this technique to achieve the customary 5-sigma threshold required for a discovery is often impractical.

To address this challenge, we propose a method based on importance sampling, which allows for estimation via simulation while reducing the required sample size by orders of magnitude. Specifically, we suggest sampling from a signal-like probability distribution, and we demonstrate that, for a broad range of scenarios, this approach optimally minimizes variance.

We will outline the mathematical proofs supporting this method and discuss its application to various synthetic examples. Additionally, we will explore the feasibility of implementing this approach in realistic experimental settings.

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