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Combined Neyman-Pearson Chi-square: an improved approximation to the Poisson-likelihood chi-square

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We present a new method to approximate the widely-used Poisson-likelihood chi-square using a linear combination of Neyman's and Pearson's chi-squares, namely "combined Neyman-Pearson chi-square" (CNP). Through analytical derivation and toy model simulations, we show that CNP leads to a significantly smaller bias on the best-fit normalization parameter compared to that using either Neyman's or Pearson's chi-square. When the computational cost of using the Poisson-likelihood chi-square is high, CNP provides a good alternative given its natural connection to the covariance matrix formalism.

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