Abstract Submitted for the MAR16 Meeting of The American Physical Society

Towards a Model Selection Rule for Quantum State Tomography¹ TRAVIS SCHOLTEN, ROBIN BLUME-KOHOUT, Sandia Natl Labs — Quantum tomography on large and/or complex systems will rely heavily on model selection techniques, which permit on-the-fly selection of small efficient statistical models (e.g. small Hilbert spaces) that accurately fit the data. Many model selection tools, such as hypothesis testing or Akaike's AIC, rely implicitly or explicitly on the Wilks Theorem, which predicts the behavior of the loglikelihood ratio statistic (LLRS) used to choose between models. We used Monte Carlo simulations to study the behavior of the LLRS in quantum state tomography, and found that it disagrees dramatically with Wilks' prediction. We propose a simple explanation for this behavior; namely, that boundaries (in state space and between models) play a significant role in determining the distribution of the LLRS. The resulting distribution is very complex, depending strongly both on the true state and the nature of the data. We consider a simplified model that neglects anistropy in the Fisher information, derive an almost analytic prediction for the mean value of the LLRS, and compare it to numerical experiments. While our simplified model outperforms the Wilks Theorem, it still does not predict the LLRS accurately, implying that alternative methods may be necessary for tomographic model selection.

¹Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energys National Nuclear Security Administration under contract DE

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Date submitted: 03 Nov 2015

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