Abstract. Among numerous approaches to the quantum state estimation, the maximum likelihood (MaxLik) principle is the most applied one due to its conceptual simplicity and advanced mathematical tools efficiently adapted to different types of Hilbert spaces and measurements. However, its known fundamental feature is the bias towards reduced rank states: Among all possibilities the method tends to select "the purest" state confirmed by a set of realized measurements. Fortunately, in most applications and for a large enough set of data, this MaxLik tendency does not limit the experimentalist's analysis of the system under study or control.

The rapidly growing field of the quantum thermodynamics also requires a precise knowledge of the system's state and evolution. The standard methods of the state measurement and reconstruction can be applied here as well. However, the MaxLik states with artificially reduced rank reveal fundamental problems when computing some of the thermodynamical quantities, like relative entropies (divergence) quantifying the irreversibility of physical processes.

In my talk I will present our cavity QED experiment simulating and quantifying various types of thermodynamical environments. The irreversibility of different open processes is characterized by entropy production whose computation requires precise knowledge of the initial and final system's states. I will explain why the rank reduction makes it impossible to properly apply the standard thermodynamical tools and how we have solved this problem by advancing the MaxLik method.