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The Rating Quality for Theoretical Description of Experimental Data

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1. $Introduction$. A new multi-parameter score-rating methodology for assessing the quality of theoretical description of experimental data in heavy-ion physics [1-11] is proposed. The approach overcomes the limitations of the traditional single-value criterion χ^2/ndf, which provides only an integral measure of agreement between theory and experiment.
The methodology is based on dividing the phase space into seven physically motivated kinematic regions of transverse momentum p_T distributions and particle ratios, corresponding to different underlying physical regimes. For each region, the quality of agreement is quantified by a score $Q_i \in [10; 1000]$ defined on a scale, ranging from very poor to excellent agreement.
A comprehensive rating R is constructed through a systematic procedure that includes region definition, weighting according to physical significance, aggregation of local scores, uncertainty estimation, stability checks, and visualization. This framework enables a transparent and comparative assessment of theoretical models, revealing their region-specific performance and complementarity.
2. $Methodology$. The phase space is divided into seven kinematic regions corresponding to different physical regimes: thermal spectra ($p_T < 0.8$ GeV/c), radial flow, hard processes relevant to QGP formation (2.5–4.0 GeV/c), medium-energy jets, high-energy jets with quenching, and the perturbative QCD regime ($p_T > 10$ GeV/c).
For each region, the local statistic is defined as:
$\mathrm{R}_i = \frac{\chi_i^2}{\nu_i}, \qquad \nu_i = N_i - kwhere\mathrm{N}_i$ is the number of data points and k is the number of model parameters.
3. $Score\ Assignment$. Based on the value of R_i, a quality score Q_i is assigned using a scale, ranging from $Q_i = 1000$ for excellent agreement to $Q_i = 10$ for very poor agreement. 4. $Weighting\ and\ Aggregation$. Weight coefficients reflect the physical significance of different kinematic regions. The aggregated quality measures include weighted averaging, geometric mean, minimum score, and dispersion penalties. 5. $Results\ and\ Discussion$. The methodology was applied to LHC data for K_S^0 mesons and Λ hyperons in p-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV. The analysis demonstrates model complementarity and sensitivity to nuclear shadowing effects. 6. $Conclusions$. The proposed score-rating methodology provides a transparent and robust framework for ranking theoretical models in heavy-ion physics and is well suited for systematic studies of LHC Run 3 data and beyond.

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