2023 progress in research

C. Parker, R.J. Fries and JETSCAPE collaborators

Bayesian Tuning of JETSCAPE

The JETSCAPE framework exists to model relativistic heavy ion collisions by combining several separate codes, such as MATTER, Pythia, and custom modules, in order to provide a universal framework for generating events [1]. Our work has been on evaluating its potential in $p + p$ and $e^+ + e^-$ systems. We do so by running the framework for a variety of parameter combinations and then using Bayesian analysis to determine which combination yields the best results compared to experimental data. Of principal interest are the MATTER and hybrid hadronization modules in JETSCAPE.

We run JETSCAPE for 3 systems, $e^+ + e^-$ at 91.2 GeV, $p + p$ at 200 GeV, and $p + p$ at 2760 GeV. $p + p$ events must be generated in sections, where we divide up the events by momentum transfer $\hat{p}_T$ in the hard scattering. The combination of both low and high momentum events is unusual for JETSCAPE runs but is critical for being able to describe the data accurately.

Results

The Bayesian tuning itself involves comparing the generated events to data for a spread of event generation parameters. They are given scores based on how well they match, and then we use a Gaussian Process Emulator to creat new simulated data for a new spread of event generation parameters. This process is repeated until the spread converges onto the values that best recreate the data. For this, the simulated data must be close enough to the actual data so that a good value can be found. The Transformation of the generated runs is shown below in Figs 1 and 2 for p+p only.

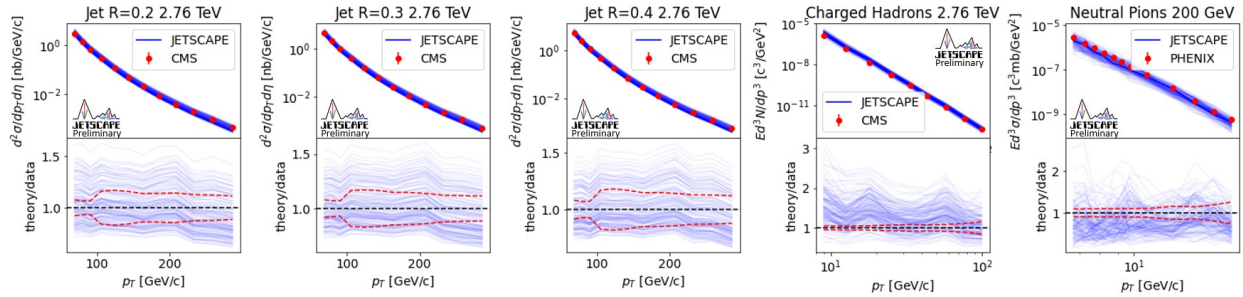

Fig. 1. Observables for the generated JETSCAPE runs before the parameter distribution is transformed. We use data from the CMS collaboration [2-4] and the PHENIX Collaboration [5]. Each blue line corresponds to a single set of parameters.

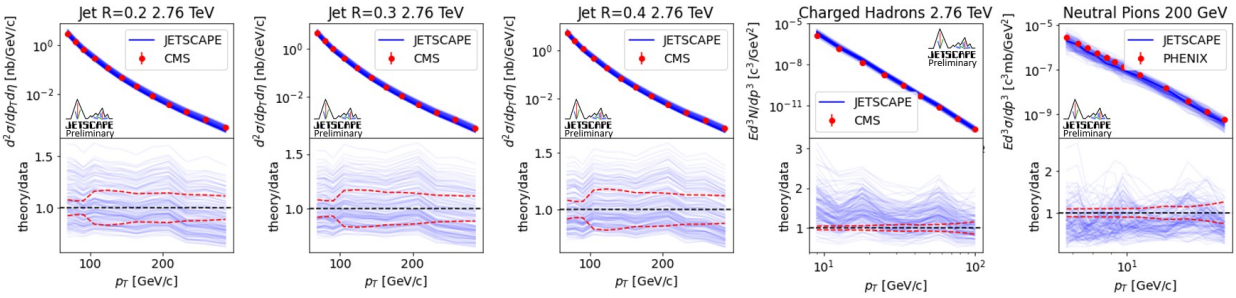

Fig. 2. Observables for the generated JETSCAPE runs after the parameter distribution is transformed. The spread narrowing corresponds to the new distribution finding a good set of values that describe the data.

Future Work

We are currently updating our spectra to use a new form of event combining. Rather than attempt to blend low and high momentum events, we are instead separating them into distinct regions and comparing them to observables specific to them. This allows us to tune over all regions. We are also using our tune to provide predictions to the ALICE collaboration for some of their heavy flavor studies.

[1] J.H. Putschke *et al.* The JETSCAPE framework (2019).
[2] ALICE Collaboration. HEPData (collection) (2014). https://doi.org/10.17182/hepdata.62520.
[3] CMS Collaboration. HEPData (collection) (2012). https://doi.org/10.17182/hepdata.58980.
[4] CMS Collaboration. HEPData (collection) (2018). https://doi.org/10.17182/hepdata.77601.
[5] PHENIX Collaboration, Phys. Rev. D **76**, 051106(R) (2007).