

Tuning JETSCAPE pp systems using Bayesian Analysis

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Introduction

JETSCAPE is a new event generation framework that has been developed to handle a wide range of high energy collisions. It is most notable for its ability to compute jets in quark gluon plasma. JETSCAPE consists of many modules working together to achieve this goal.

In this analysis, we use Bayesian analysis methods to develop a parameter tune for JETSCAPE to simulate proton-proton collisions. We use parameters in all major modules used for this calculation: PYTHIA 8, MATTER and Hybrid Hadronization. We include jet and charged hadron spectra at LHC and charged hadron spectra at RHIC energy in the analysis. We follow up by including JETSCAPE e^+e^- simulations and the pertinent data.

Event Pipeline

1. PYTHIA 8 generates the initial hard scattering plus MPI and the underlying event.
2. The partons radiate through the strong interaction to produce a shower of partons. This calculation is done through MATTER.
3. The partons are allowed to recombine into hadrons using Monte Carlo methods using Hybrid Hadronization. The remaining partons form color strings.
4. The color strings are then broken up into hadrons with PYTHIA's fragmentation module.

Event Combining

We break up event generation into \hat{p}_T ranges for PYTHIA to handle the initial scattering process. For each event, we start with 2 partons to directly scatter with hard QCD. \hat{p}_T refers to the magnitude of the transverse component of the momentum exchanged. Hadron spectra for p_T less than 6 GeV are constructed separately with a single \hat{p}_T range from 0 to infinity run on soft QCD. The hard and soft regions have no mixing and the observables are constructed entirely separately.

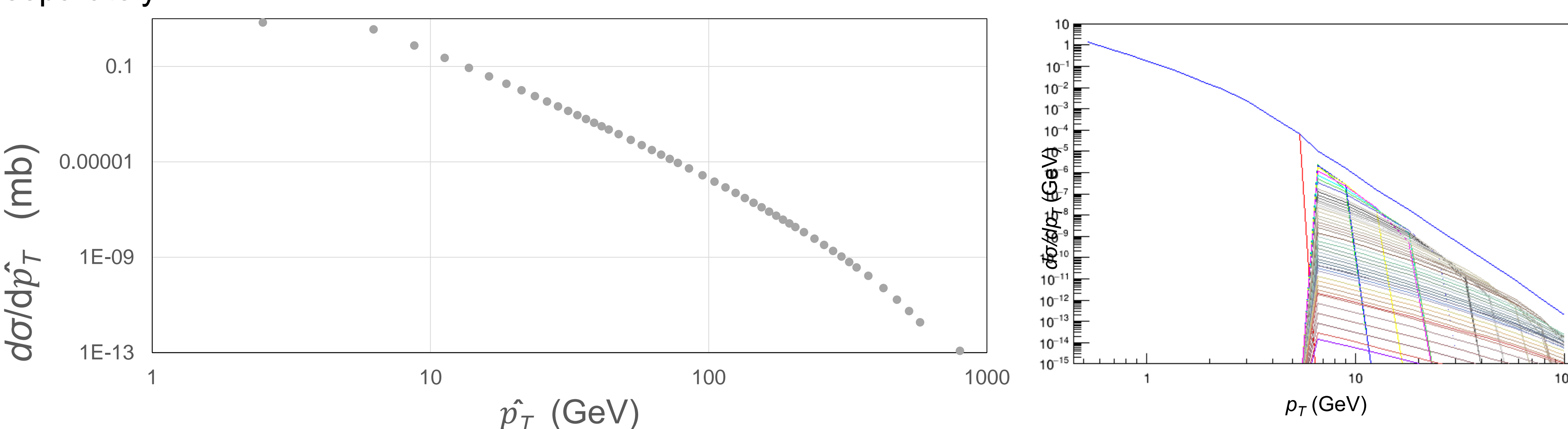


Fig. 1: Production cross sections for each \hat{p}_T range (left) and identified charged hadron spectra for each bin (right). The blue line on top is the total spectrum produced by adding all individual spectra together. Note how each spectra falls off as it passes the \hat{p}_T limit for the bin.

Observables

Below we present the results for proton-proton collisions, run at both 200 GeV (RHIC) and 2760 GeV (LHC). We see that JETSCAPE successfully produces smooth distributions for the jets in the LHC collisions and individual hadron spectra for regions dominated entirely by hard QCD. It struggles, however, to do this with the identified pions for RHIC. These collisions produce less particles, reducing our statistics. Although data is available for soft QCD regions, we focus on the hard QCD regions since we can accurately recreate those collisions. In the future we will include e^+e^- , but we wait for an improved e^+e^- to become available in JETSCAPE 3.6

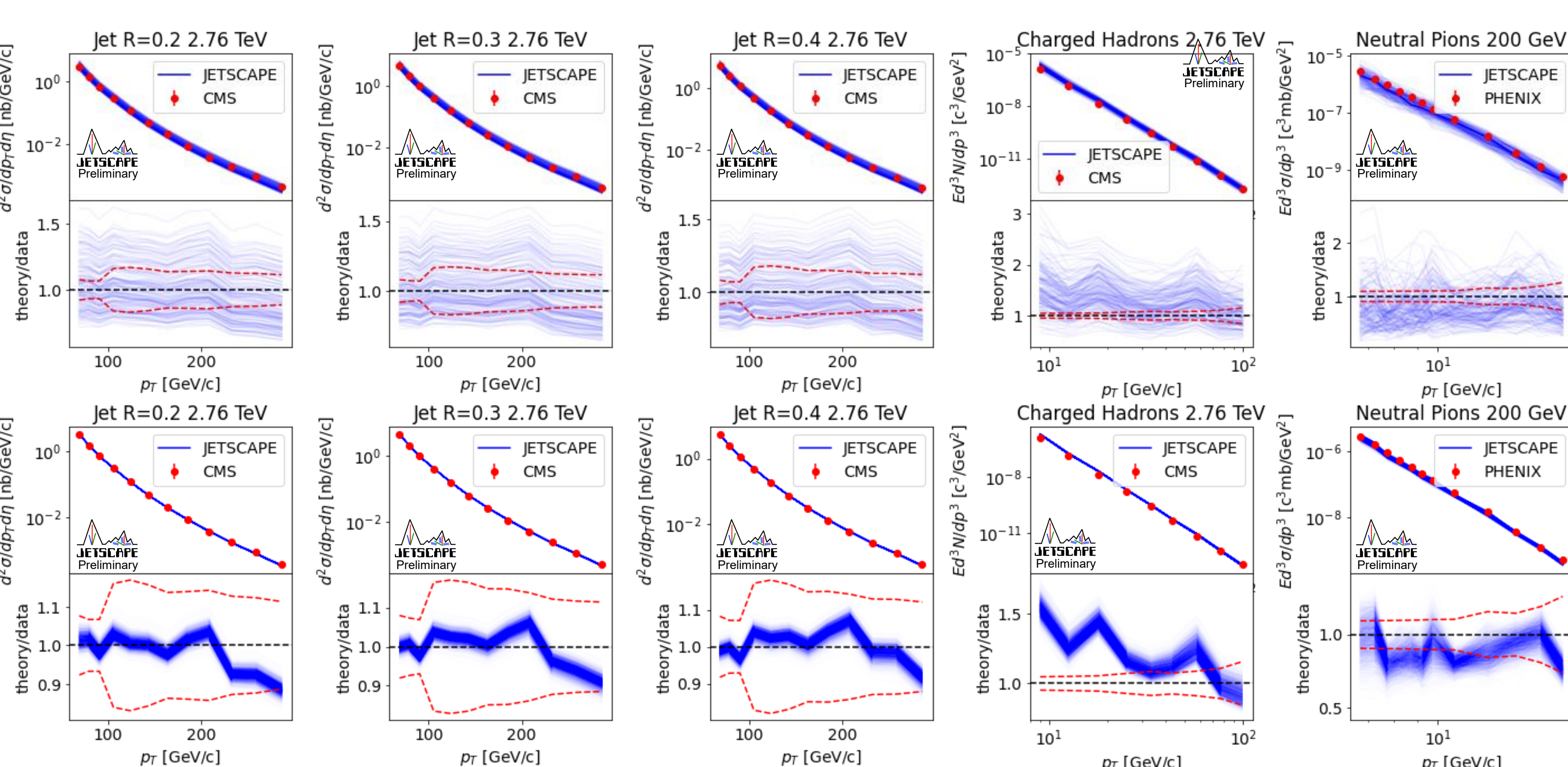
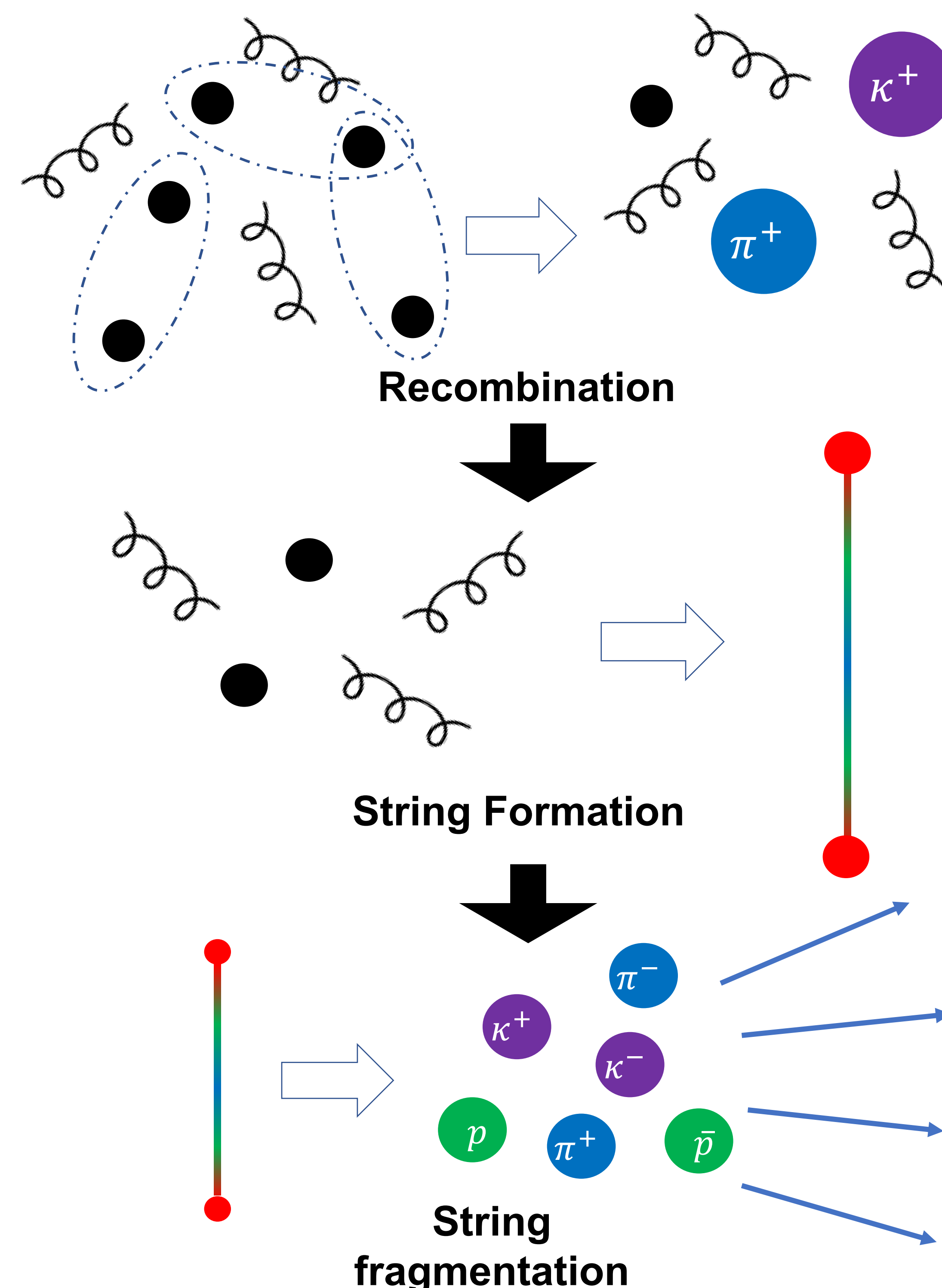
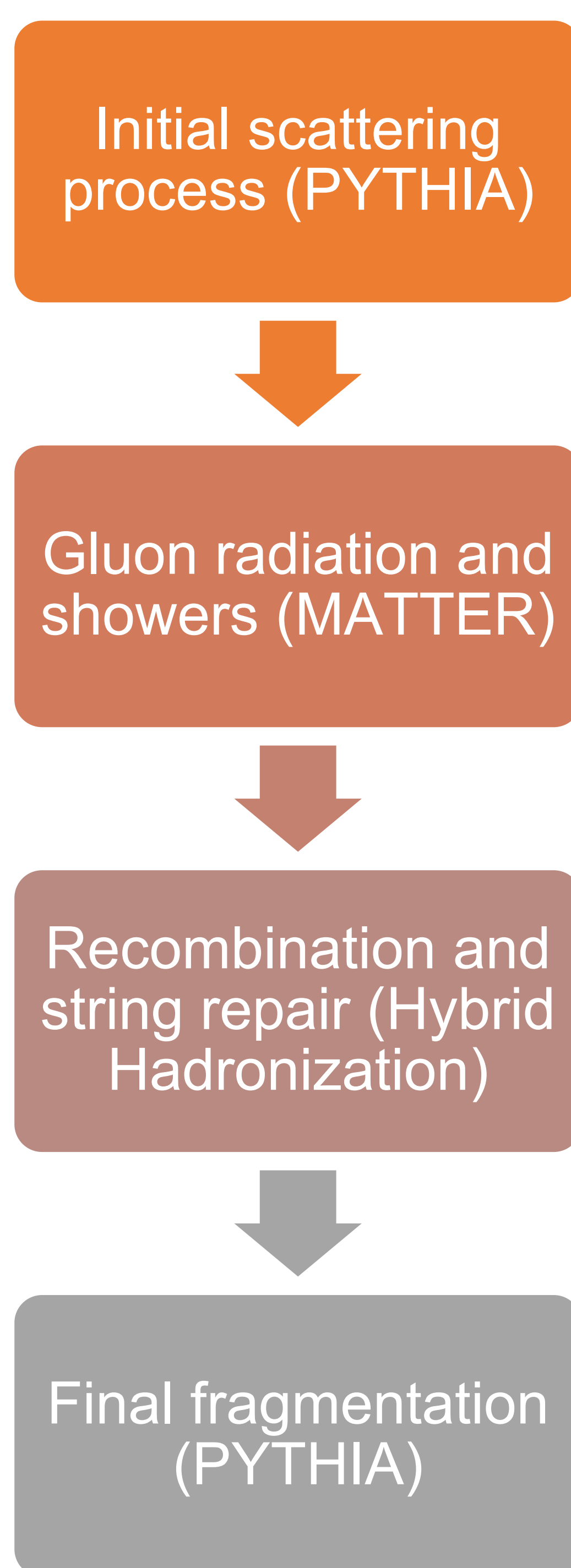


Fig. 2: JETSCAPE results for proton-proton collisions with priors (top) and posteriors (bottom). From left to right, the spectra are LHC jets ($r = 0.2$), LHC jets ($r = 0.3$), LHC jets ($r = 0.4$), LHC total charged hadron spectra, and RHIC neutral pion spectra.
LHC jets: <https://doi.org/10.17182/hepdata.77601>.
LHC hadrons: <https://doi.org/10.1140/epjc/s10052-012-1945-x>
RHIC: <https://doi.org/10.17182/hepdata.85695>.



Tune Parameters

- Virtuality factor (0.1-1): 0.478.** determines starting virtuality for every shower initiating parton as a portion of its initial momentum
- Q_0 (0.9-3 GeV): 2.29 GeV.** Virtuality threshold for when perturbative QCD stops
- λ_{QCD} (0.1-0.4 GeV): 0.292.** strength of QCD interactions in MATTER
- Hadron scales (0.5-2): 0.92, 1.19, and 1.31.** factor multiplying the measured wavefunction widths for pions, kaons, and protons
- Strange to up-down ratio (0.2-0.5): 0.206.** rate strange quarks are produced compared to 1st generation quarks in string fragmentation
- Diquark to quark ratio (0.07-0.2): 0.114.** rate diquarks are produced compared to single quarks in string fragmentation

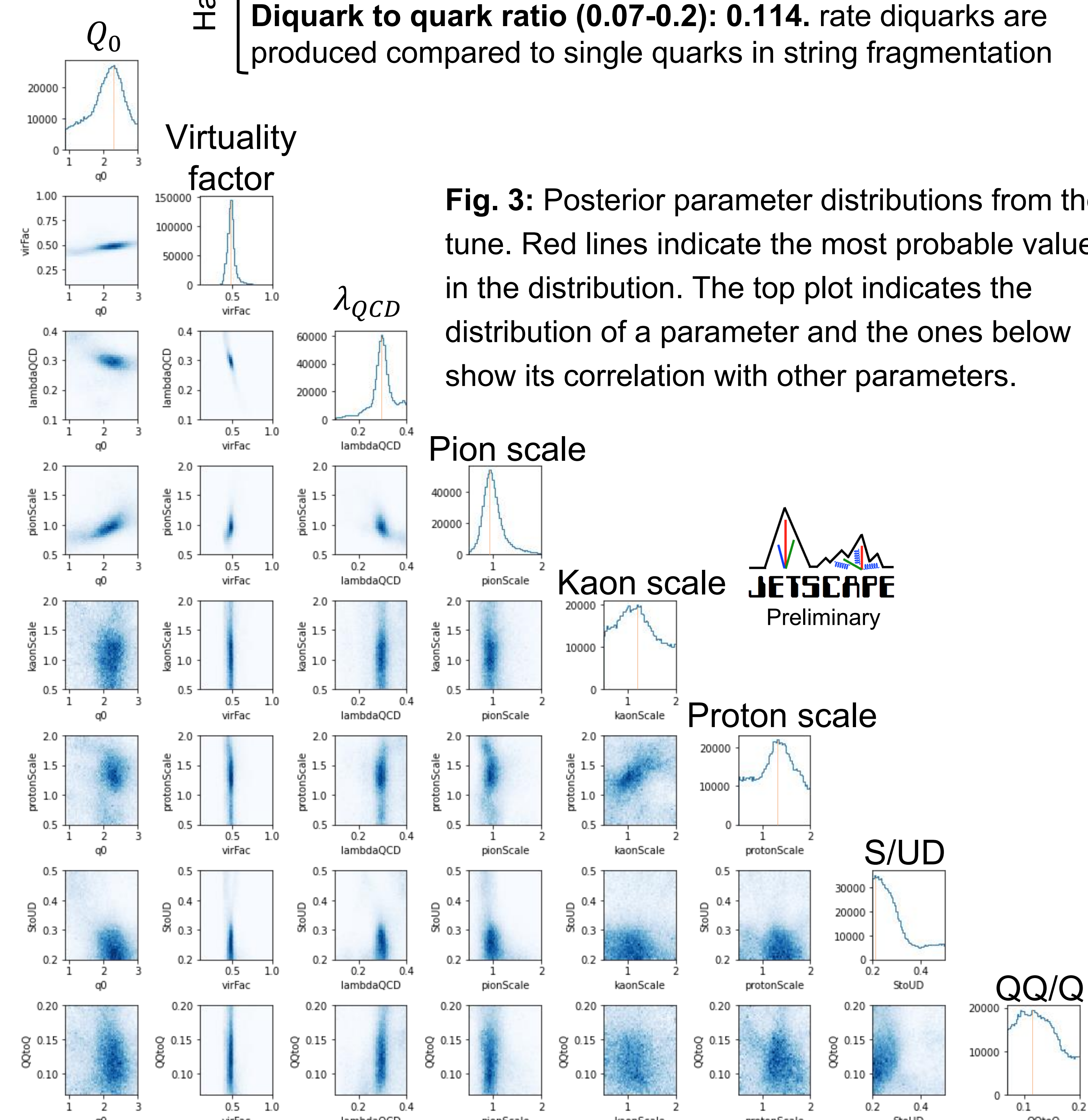


Fig. 3: Posterior parameter distributions from the tune. Red lines indicate the most probable value in the distribution. The top plot indicates the distribution of a parameter and the ones below show its correlation with other parameters.