Bayesian inference for heavy-ion collisions with JETSCAPE

SciDAQ Discussion

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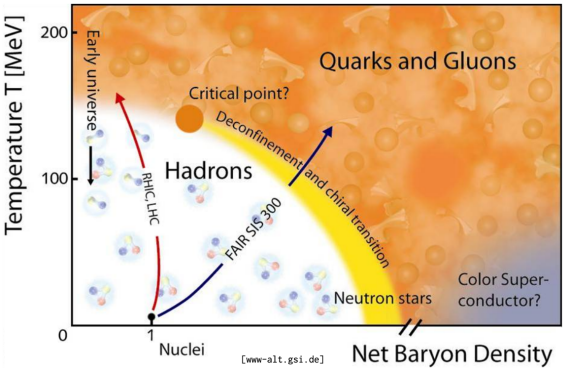
Heavy-ion collisions and the quark-gluon plasma

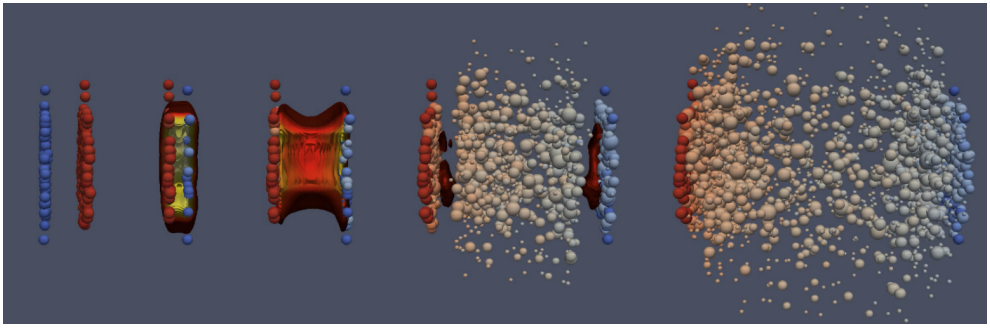
- At high temperatures, hadrons melt into their constituent quarks and gluons
  - Transition from hadronic to partonic degrees of freedom
- The quarks and gluons are deconfined in a strongly coupled state known as the **Quark Gluon Plasma (QGP)**
- Phase transition occurs around a temperature of $T \sim 150$ MeV
- Trajectories through the phase-space are experimentally accessible in heavy-ion collisions



- Aim to understand QGP properties, structure

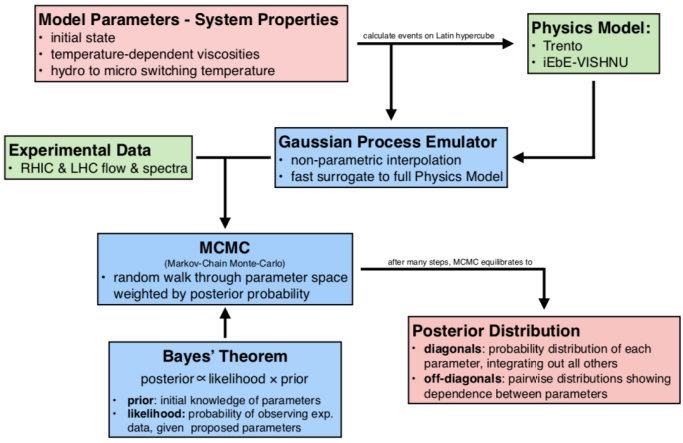
Heavy-ion collisions and the quark-gluon plasma

- Collisions can be described via different phases



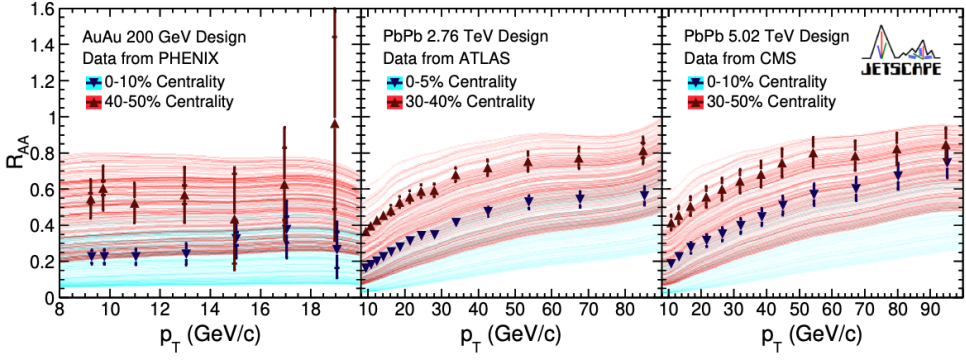
- Wealth of observables and theories, but difficult to model and disentangle
- JETSCAPE collaboration of experimentalists, theorists, statisticians, CS to develop **multi-stage** model, detailed tools for **data-theory comparison**

Bayesian parameter estimation



Extraction of jet transport coefficient $\hat{q}$

- Recently extracted the jet transport coefficient, $\hat{q}$, characterizing the momentum transfer between a propagating parton and the QGP.
- Utilize Bayesian Parameter Estimation to constrain model parameters



Phys.Rev.C 104 (2021) 2, 024905
Phys.Rev.Lett. 126 (2021) 24, 242301
Phys.Rev.C 103 (2021) 5, 054904

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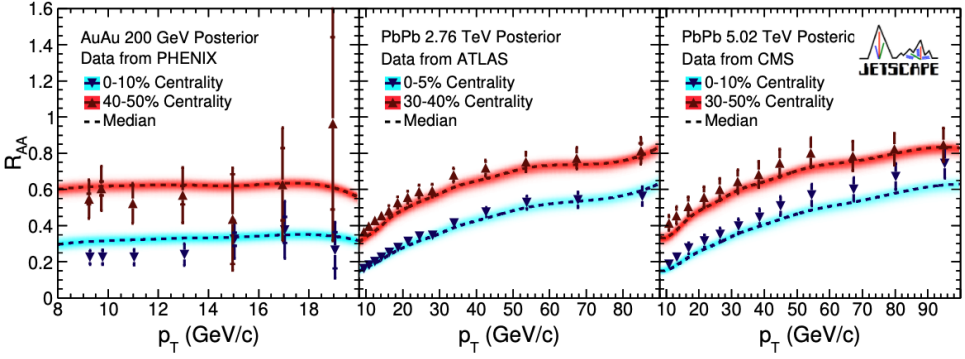

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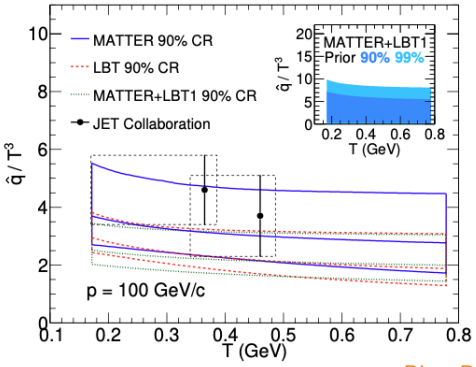

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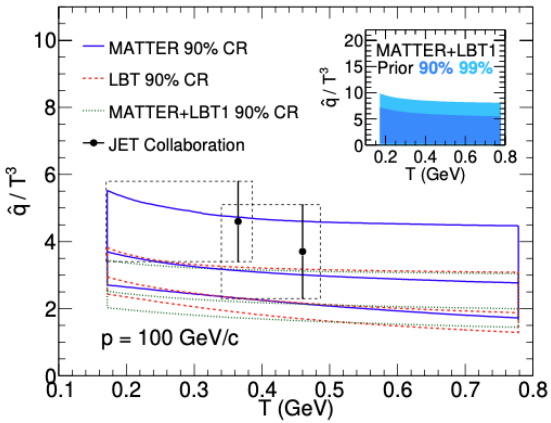
Looking towards the future

- Still much to be done for data-model comparison in heavy-ion collisions
  - Next generation analysis are in progress
- Major challenge due to **high required computing time**
  - Hit limits of HPC allocations
- **More efficient emulation** is critical!
- Transfer learning
- Multi-fidelity models
- Improved handling of correlated errors between observables

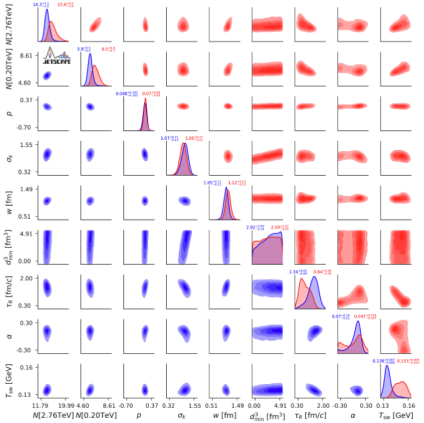
→ See Simon's talk



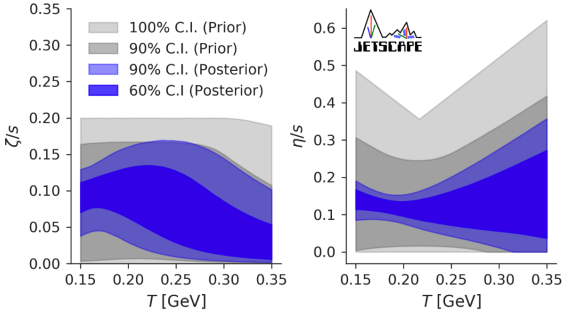
Backup

Extraction of soft sector parameters

Extracted posteriors



Temperature-dependence of specific shear and bulk viscosities



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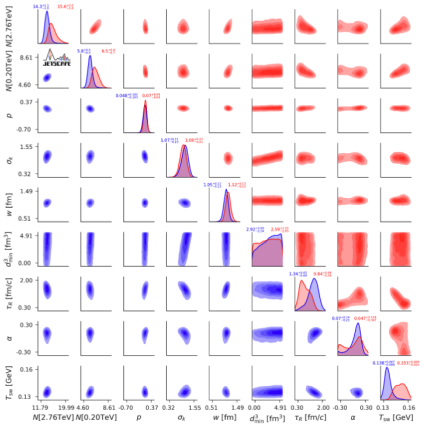

Provide relative comparison of
3 particlization models