Quantifying the Properties of QCD Matter with Relativistic Heavy Ion Collisions

(white paper available)

2007 Long-Range Plan

The major discoveries in the first five years at RHIC must be followed by a broad, ***quantitative*** *study of the fundamental properties of the quark-gluon plasma. This can be accomplished through a 10-fold increase in collision rate, detector upgrades, and advances in theory. The RHIC II luminosity upgrade, using beam cooling, enables measurements using uniquely sensitive probes of the plasma such as energetic jets. and rare bound states of heavy quarks. The detector upgrades make important new types of measurements possible while extending significantly the physics reach of the experiments.* ***Achieving a quantitative understanding of the quark-gluon plasma also requires new investments in modeling of heavy-ion collisions, in analytic approaches, and in large-scale computing.***

Quantitative Properties

1a. Eq. of State (μ=0)
1b. Eq. of State (μ≠0)
2. Chemical make-up
3. Chiral symmetry restoration
4. Heavy resonances
5. Viscosity
6. Diffusion
7. Jet-Energy Loss
8. Saturation
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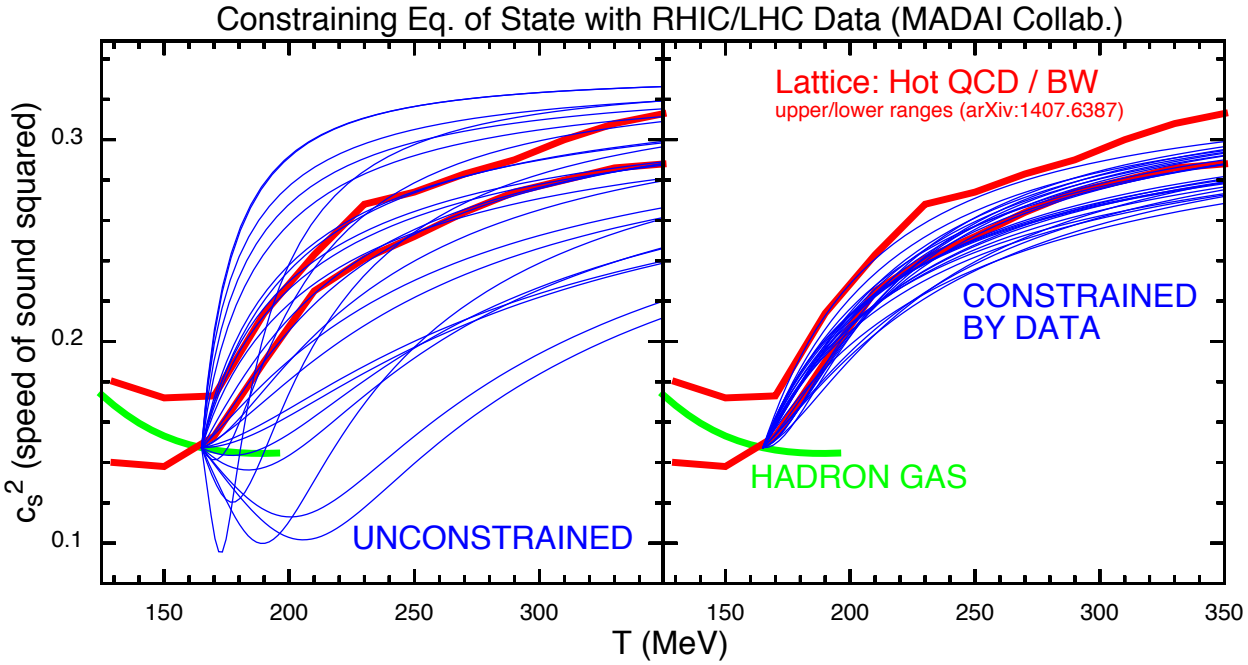
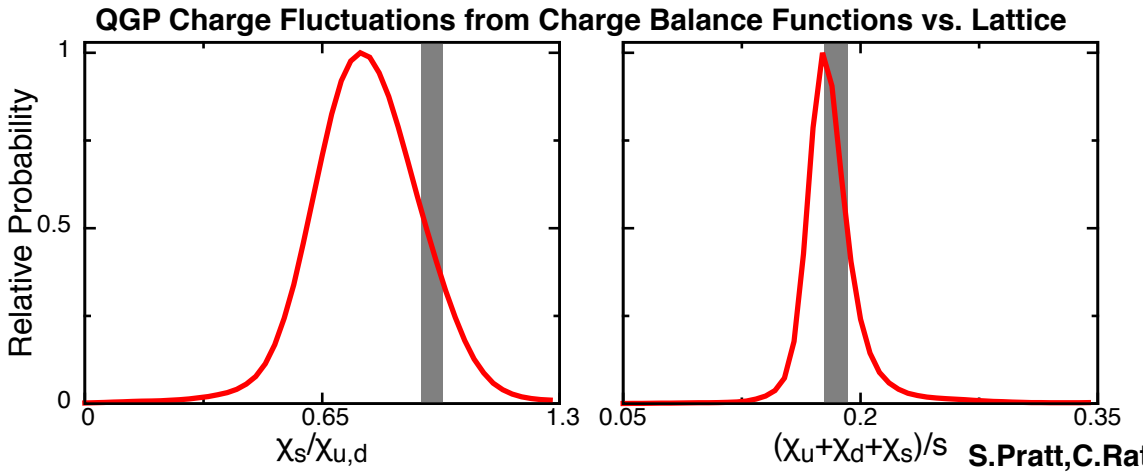


Statistical Analysis

STRATEGY

- **Collect Data**
  - **Express uncertainties**
- **Parameterize Models (perhaps dozens)**
  - **Initial state + hydro + cascade …**
- **Compare models to data**
  - **Use model emulator**
  - **~1000 samplings of parameter space**
  - **Explore likelihood with MCMC**
- **Results can:**
  - **A. Determine parameters with uncertainties**
  - **B. Provide validated foundation for studies**
  - **C. State whether collisions created matter with same properties as lattice**



S.Pratt,C.Ratti&W.P.McCormack (arXiv:1409.2164)

Goals

Quantitative Properties

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What is needed

- Better Understanding of Current Data
- More Detailed Experimental Analysis
- New Data (BES)
- Improved Modeling
  - 3D Hydro
  - Initial state
  - Diffusion
  - Description of transition region
  - Overlaying jets/heavy flavors onto 3D evolution
  - ….
- Computational Resources
  - Statistics to compare to data x 1000
- Collaboration, Cooperation, Coordination
  - Theory-Theory, Theory-Exp, Exp-Exp